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THE GENITO-URINARY SYSTEM OF THE INDIAN GROUND SQUIRREL (*FUNAMBULUS PALMARUM*)

By M A H Siddiqi
King George's Medical College Lucknow

Received March 11 1938

SUMMARY

The gross anatomy of the male genito-urinary system of the common Indian ground squirrel (***Funambulus Palmarum***) has been described A microscopic study of the entire lower portion of the system has also been made Attention has been drawn to the following features —

1 The prostate gland is extra urethral in situation and is connected with the urethra by one pair of ducts only

2 The duct of the prostate gland and that of the seminal vesicle open independently into the urethra.

3 The os penis is present and has been shown to be the ossified anterior end of the crura penis

4 In the American ground squirrel, ***Citellus tridecemlineatus***, the bulbo urethral and bulbar glands along with the penile duct have been found to be developmentally ectodermal in origin and the proximal two-thirds of the penile urethra is purely endodermal in origin

INTRODUCTION

Funambulus Palmarum is found abundantly in a wild state throughout the Gangetic plain in Northern India Specimens were trapped alive and chloroformed, the genito-urinary system was removed *en bloc* and fixed in formalin Three blocks, one of each of the following groups of structures, were embedded in celloidin and cut serially at 15-30 micra —

(1) bladder and muscular urethra with the prostate gland and seminal vesicle *in situ*

(2) proximal 2/3rds of the penile urethra with Cowper's gland and the penile duct

(3) terminal 1/3rd of the penile urethra and the os penis

Sections were stained with hæmatoxylin and eosin Graphic reconstruction method was adopted for the tracing of ducts and other structures,

THE GENITO-URINARY SYSTEM

The kidneys, Ureters, Bladder and Urethra —The kidneys have the usual characteristics of a mammalian metanephros They lie one on either side of the vertebral column in the lumbar region embedded in the retro-peritoneal fat.

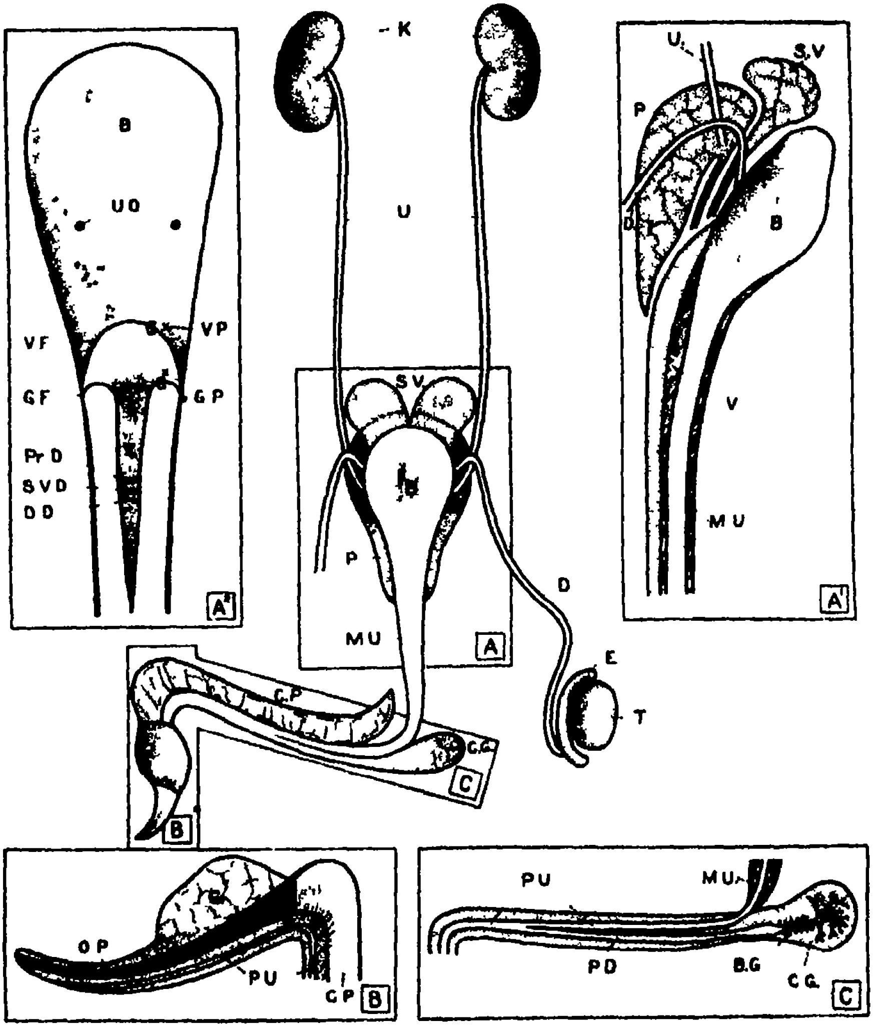

Fig 1

Genito urinary System of ***Funabulus Palmarum***

A^1 Sagittal section of block A The ductus deferens is seen to cross the ureter and the seminal vesicle to occupy the most median situation The three ducts are seen to lie in the interval between the prostate gland and the neck of bladder

A^2 Interior of the bladder and muscular urethra The vesical fold, genital fold and verumontanum are seen The separate orifices of the three pair of ducts are shown

B Sagittal section of block B The ossified anterior end of the crura (the os penis) evaginates through the substance of the glans

C Sagittal section of block C The penile duct which drains the bulbo-urethral and bulbar glands runs ventral to the penile urethra surrounded by cavernous tissue and enclosed within the same sheath as the urethra.

B Bladder, *Pr D*, Duct of prostate gland *G* Glans *U O* Ureteral orifice *S V D* Duct of Seminal vesicle *P D* Penile Duct, *V F* Vesical fold, *D D* Ductus deferens, *M U* Muscular Urethra, *G F* Genital fold, *U* Ureter, *B G* Bulbar gland, *G P* Genital pouch, *P* Prostate, *O P* Os penis, *C G* Cowper's gland, *V* Verumontanum, *P U* Penile urethra, *C P* Crura penis, *E* Epididymis, *T* Testis, *K* Kidney *N B* Neck of Bladder, *U C* Urethral crest,

The thin ureters, surrounded by a sheath of fatty tissue, descend to the base of the bladder The bladder when distended is very thin-walled and translucent, and rises above the pelvic brim covered on all sides by the visceral peritoneum It is freely movable ventro-dorsally at its neck which is attached to the muscular and, comparatively firmly fixed, prostatic urethra When empty it is a pale yellow, globular, and solid-looking organ lying in front of the prostate and the seminal vesicles which project to a more cranial level than the bladder itself The first or muscular part of the urethra runs caudally between the rectum on the dorsal side and the symphysis pubis on the ventral side, and tapers from a broad base at its junction with the bladder to a narrow apex in the perineal region where it becomes continuous with the penile urethra at almost a right angle It is semi-cylindrical with a flat dorsal wall which lies in close contact with the rectum The distinction of this part of the urethra into a prostatic and a membranous part hardly seems justifiable because in serial sections it shows a uniform structure all along although the muscular coat gradually diminishes in thickness towards the perineum

Since the prostate gland lies entirely outside the urethral wall and is only connected with the latter by a pair of prostatic ducts, a distinct prostatic part of the urethra does not exist I shall therefore call the entire pelvic portion the *muscular urethra* since we cannot distinguish separate prostatic and membranous parts in it.

The mucous folds in the muscular urethra of the Indian squirrel are very constant and characteristic The neck of the bladder invaginates into the urethra in its dorsal part in the form of a semi-lunar fold with the consequent formation of a pouch behind it. About 3 mm below this fold there is another identical semi-lunar fold with a second pouch behind it, this latter pouch is bilocular on account of the elevation of the verumontanum which is attached to this fold mid-dorsally and conveys the three pairs of genital and accessory genital ducts

The second or penile portion of the urethra begins in the perineum ventrally to the anal canal and has enclosed within its own sheath the penile duct, which runs ventral to it for about two-thirds of the penile length before it becomes confluent with the urethra Cranially the penis has a sharp ventral bend and ends in a beak-shaped glans containing the os penis To the naked eye the os penis is embedded proximally in an oblong reddish swelling of the glans at the root of which the prepusial fold of skin is attached The two crura which form the main body of the penis are therefore separate structures only at their attachment to the pelvic bone The main body of the penis, formed by the fused dorsally situated crura, presents a deep ventral groove into which is lodged the corpus cavernosum surrounding the penile urethra and duct The corpus cavernosum urethrae is uniformly tubular in shape and easily strips away from the crural groove The terminal part of the penis, distal to the ventral bend, is beak-shaped and has two parts, a proximal which is oblong in shape, comparatively soft and reddish brown in colour, and a distal part which is whitish and bony The urethra and the penile duct, while they are embedded in the crural groove, are surrounded by a thin layer of cavernous tissue which greatly increases in size in front and forms the oblong swelling at the base of the glans The crura traverse the dorsal part of the glans and terminate in the os penis which is really the ossified anterior extremity of the crura The urethra traverses the glans ventrally to the base of the os penis and continues its forward course on the ventral convex aspect of the bone, surrounded only by a thin layer of soft tissue, and opens near the tip of the bone

The Testis —The testis are lodged within a semi-pendant, dark-skinned scrotum, the glands have a glistening white surface while the enveloping tunica albuginea shows tortuous blood-vessels The epididymis possesses both a pronounced head and a tail connected by a narrow body which half encircles each testis The vas deferens emerges from the tail of the epididymis and, accompanied by the spermatic vessels, reaches the pelvic brim through the inguinal canal, thence it courses its way through the narrow area between the prostate and the seminal vesicle on the dorsal side and the base of bladder on the ventral While traversing this area the vas deferens runs caudal-wards parallel to the duct of the opposite side, gradually pierces the wall of the muscular urethra and opens into its lumen The vas deferens does not join with the duct of the seminal vesicle, but both of them open independently into the urethra and consequently there is no formation of an ejaculatory duct This is a characteristic feature which requires comparative study and embryological investigations

The Prostate —In a fresh specimen the prostate is a compact bilaterally symmetrical gland, lying in apposition to the posterior part of the neck of the bladder and the dorsal part of the muscular urethra When the bladder is full, it extends beyond the anterior margin of the prostate gland which, with the fat lying in front, presents the appearance of a collar round the vesical neck The gland is pyramidal in shape with its apex directed posteriorly and the base facing the abdominal cavity and lying against the coils of the intestine Its anterior surface is concave and forms a bed for the fundus of the bladder, the lateral surfaces are convex and are adapted to the shape of the pelvic cavity, while posterior surface presents a median groove for the lodgment of the rectum The apex is closely applied to the posterior part and the side of the neck of the bladder and the upper part of the muscular urethra When the gland is dissected in water, one can easily distinguish a pair of lobes, each of which is drained by a separate duct These ducts pierce the sides of the muscular urethra and open into its lumen The whole gland, therefore, lies outside the urethra, the only connection between the two being through the pair of ducts which open into the latter

The gland is invested externally by a thin capsule of areolar and fibrous connective tissue which also penetrates into the substance of the gland and divides it into a number of lobules Each lobule consists of closely packed tubules, the cells lining the tubules being regularly arranged in a single layer At certain places, which are perhaps regions of greater activity, villous processes project into the lumen of the tubules The lobules adjoining the *muscular urethra* have sharply defined circular tubules with flattened cells, these presumably function as ducts for carrying the secretion of peripherally situated active tubules

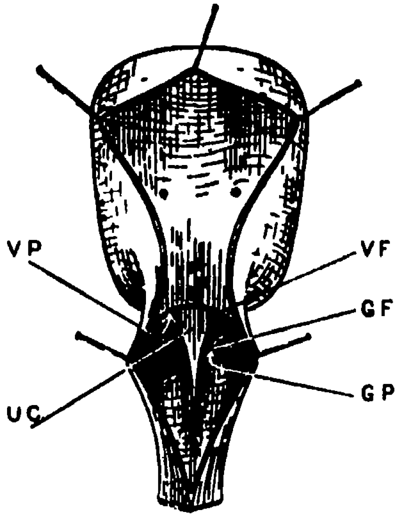

Fig 2

The Muscular Urethra slit open from ventral side to demonstrate the Folds and Pouches (Diagrammatic)

Lettering as in Fig 1

The Seminal Vesicles —The seminal vesicles are conical in shape and lie ventrally to the prostate gland. Their bases are crenated in appearance and lie freely at the inlet of the pelvis, thus making it difficult to see the prostate gland from the front. The narrow apex of each vesicle is continued into its duct, and is whitish in appearance but disappears behind the bladder, between it and the prostate gland On opening the narrow space between the posterior surface of the bladder and the anterior surface of the prostate, the duct of the seminal vesicle may be seen to pierce the urethral wall laterally to the ductus deferens

The Prostatic Utricle —Even a very careful search made in my serial sections failed to reveal any trace of this organ

The Bulbo-Urethral Glands —These glands lie on either side of the anal canal and their two ducts converge and join with the median bulbar gland to form a single penile duct which runs ventrally to, and in the same sheath with, the penile urethra The two ducts, namely, the penile urethra and the ventral penile duct, are a constant feature of the serial sections passing through the proximal two-thirds of the penis In the terminal one-third the two ducts become confluent

DISCUSSION

Certain features in the anatomy of the genito-urinary system require special consideration in view of my study of the embryology of the American ground squirrel or spermophile[10] (*Citellus tridecemlineatus*) the genito-urinary tract of which is almost identical anatomically with that of *Funambulus palmarum*

The prostate gland, unlike that of man, lies completely outside the wall of the urethra, being connected with the latter only by a pair of prostatic ducts There is no anterior lobe of the gland Embryologically the gland seems to develop very much like the pancreas or the liver of vertebrates A pair of diverticula are given off from the urogenital sinus, the proximal part of which form the two ducts while the distal parts give rise, by repeated and rapid proliferation outside the urethral wall, to the large prostate gland The large size and independent existence of this gland is a very favourable adaptation to the increased activity of this gland in Rodents In man the diverticula, although numerous, do not develop sufficiently to evaginate out of the urethral wall and the gland in the adult remains permanently lodged within the urethral wall, consequently, if the gland undergoes hypertrophy the lumen of the urethra is more or less occluded and leads to a retention of urine

The arrangement of the three pairs of ducts, i e , ducti deferentes, ducts of the seminal vesicles and the prostatic ducts, requires to be explained by an embryological investigation, which I have not been able to complete for want of sufficient proper material In the case of the spermophile and the Indian squirrel, where the ductus deferens and the duct of the seminal vesicle open separately into the urethra, I believe that the developmental processes involved in the separation of the seminal vesicle diverticulum (duct of seminal vesicle) from the Wolffian duct (ductus deferens) is identical with that observed in the separation of ureteral bud (ureter) from the Wolffian duct.

An increase in the pars pelvina of the urogenital sinus encroaching upon and engulfing the terminal part of the Wolffian duct situated distally to the seminal vesicle diverticulum leads to the separation of the ductus deferens and the duct of the seminal vesicle, each having an independent opening into the urethra.

This terminal part of the Wolffian duct forms the ejaculatory duct in man.

An indication that such a process is probable is provided by the condition obtained in the red squirrel (*T. hudsonicus*) in which it appears that the urogenital sinus, although it has engulfed the whole of the ejaculatory duct, has not gone farther than the point on the Wolffian duct where the seminal vesicle diverticulum arises, so that the two ducts have a common orifice into the urethra. The condition in the grey squirrel (*S. carolinensis*) on the other hand, is hard to explain theoretically. The main problem is the identity of the common duct formed by the junction of the ductus deferens, the duct of seminal vesicle, and the prostatic duct. There seems to be only two possibilities (1) that it is the ejaculatory duct, and that the prostatic duct happens to open into it only secondarily, the prostate gland being primarily derived by an evagination from the urogenital sinus, (2) that this entire duct is an evagination from the uro-genital sinus which has engulfed the ejaculatory portion of the Wolffian duct (*identical with the condition in the spermophile*) and has the opening into it of the prostatic duct (*the prostate gland being developed from this part of the urogenital sinus*). I am inclined to believe that the latter is the more likely possibility.

The seminal vesicles are glandular in structure and their alveoli which are filled with mucilaginous material never show the presence of spermatozoa. The arrangement of the ducts strongly suggests that the vesicles are purely secretory in function and does not store spermatozoa at all.

The prostatic utricle is absent both in the case of the spermophile and the Indian squirrel. After studying the development of the Mullerian ducts in the series of spermophile embryos I concluded that the absence of the prostatic utricle from the adult urethral wall is due to the nonformation of the vaginal (Frazer) or the Sino-vaginal (Koff) bulbs from the urogenital sinus, associated with a complete retrogression of the Mullerian ducts.

The muscular urethra, as the name suggests, possesses a thick coat of smooth circular muscle-fibres along its entire length which is continuous cranially with the comparatively thin-walled bladder.

The homology of the bulbo-urethral gland, bulbar gland and the penile duct has been discussed by Mossman and other previous investigators on the subject

I have been able to study the embryology of this region in the case of spermophile and have come to the conclusion that the bulbo-urethral gland, bulbar gland, the penile duct and the terminal part of urethra lying distally to the orifice of penile duct are purely ectodermal in origin and are homologous with (1) the bulbo-urethral gland, (2) the floor of about the proximal two-thirds and (3) the whole terminal one-third of the penile urethra in man The penile urethra, proximal to the orifice of the penile duct, is purely endodermal, being derived from the urogenital sinus It is homologous with the roof of the proximal two-thirds of the urethra in man It is significant to note in this connection that in the urethra of man the lacunae are found only along the endodermal roof and so that the lacuna magna, marks perhaps the anterior limit of the extension of the urogenital sinus Mossman*[8] suggested the ectodermal origin of the bulbo-urethral gland as a possibility which I believe is correct

The os penis is homologous with the anterior end of the crura in man In the Sciuridae the anterior ends of the crura become ossified and are pointed into a beak-shaped process which pierces through the substance of the glans, evaginates and carries a thin layer of glandular tissue over it.

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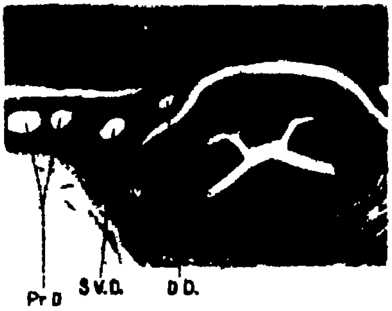
* A well preserved series of the embryos of the spermophile was kindly sent to me by Dr H W Mossman of the University of Wisconsin (U S A) My findings on these embryos have been published separately (10, 1937)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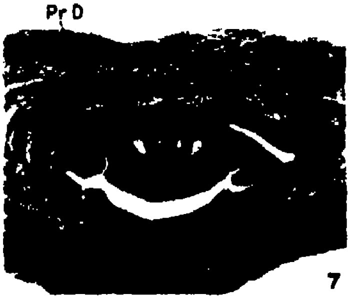
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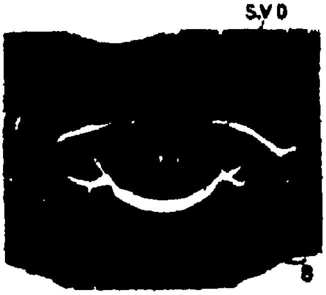
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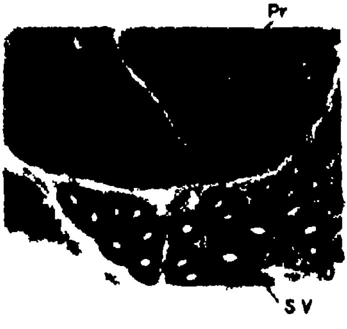
Pr
10
S V

B.U.G

D.B.U.G

B.G
13

U
PD
14

EXPLANATION OF PLATE 1

These Photographs are all of a sexually inactive Indian ground squirrel (***Funambulus palmarum***)

Figures 3 and 4 The three pairs of ducts are seen entering through a hiatus in the muscularis at the neck of the bladder

5 The ducts have entered the muscularis

6 The ducts are running in the submucosa The ducts of prostate gland have migrated well in towards the lumen of urethra

7 The ducts are in the substance of the verumontanum The left prostatic duct has opened out The genital fold and the pouch behind it is seen on the left side

8 Both the prostatic ducts have already opened out The duct of left seminal vesicle is opening Genital fold and the pouch are pronounced on both the sides

9 The duct of seminal vesicle and the ductus deferens are opening separately on the left side

10 Section showing parts of the seminal vesicle and the prostate gland in the same field The two glands are structurally quite different

11 Section through the posterior part of the bulbo urethral gland showing the major *collecting* ducts

12 Section showing the ducts of bulbo urethral glands passing through the bulbar gland

13 Section through the bulbar gland showing the common cavity (beginning of the penile duct)

14 Section through the proximal portion of penile urethra showing the urethra and the penile duct surrounded by cavernous tissue and enclosed within a common sheath

B U G Bulbo-urethral gland *U* Urethra *B G* Bulbar gland, *D B U G* Duct of bulbo urethral gland *P D* Penile Duct *Pr. D* Duct of Prostate gland, *C C* Corpus cavernosum, *Se D* Duct of Seminal Vesicle *Pr* Prostate gland *S V* Seminal vesicle *D D* Ductus Deferens

ON A NEW SPECIES OF THE GENUS *ASTIOTREMA* LOOSS, 1901, FROM THE INTESTINE OF A FRESH WATER FISH, *CLARIAS BATRACHUS* (FROM LUCKNOW)

By J Dayal

Department of Zoology, Lucknow University

Received March 3, 1938

SUMMARY

Astiotrema dassia is a small trematode 2·2 mm long by 0·42 mm broad The skin is covered with spines Oral sucker is equal to ventral sucker Prepharynx is absent, pharynx and oesophagus are well developed, the intestinal caeca run up to the posterior end of the body Genital opening is situated in front of the ventral sucker a little to the right. Testes are slightly lobed and tandem in position Cirrus sac is large and extends up to the ovary Receptaculum seminis is small Vitelline glands extend from the ventral sucker to the posterior end of the hinder testis. The relationship of the form is discussed and a key to the species of the genus is given in the paper

Looss (1899) erected the genus *Astia* to include *Astia impletum* and *Astia reniferum* (*Distomum, reniferum* Looss, 1898) Looss (1901) changed the generic name to *Astiotrema,* the name *Astia* being preoccupied, and both the species were included in the genus Since then several species have been described and added to the genus which now contains the following species —

1 *A impletum*, Looss (1899), 2 *A reniferum*, Looss (1898), 3 *A monticelli*, Stossich (1904), 4 *A emydis*, Ejsmont (1930), 5 *A elongatum*, Mehra (1931), (Syn *A gangeticus*, Harshe 1932), 6 *A loossi*, Mehra (1931), 7 *A indica*, Thapar (1933), 8 *A spinosa*, Chatterji (1933), 9 *A odhneri*, Bhalerao (1936), 10 *A rami*, Bhalerao (1936), 11 *A orientale*, Yamaguti (1937)

The form described in the present communication differs from others in important characters and hence the necessity of erecting a new species

Astiotrema dassia, N Sp

Astiotrema dassia is a small cylindrical trematode with rounded anterior and posterior ends It is 2·2 mm long by 0·42 mm broad in the region of the ootype The skin is covered with small backwardly directed spines

The oral sucker is circular and subterminal in position It is 0·14 mm in diameter The acetabulum is circular and equal to the oral sucker It is situated at a distance of 0·65 mm from the anterior end

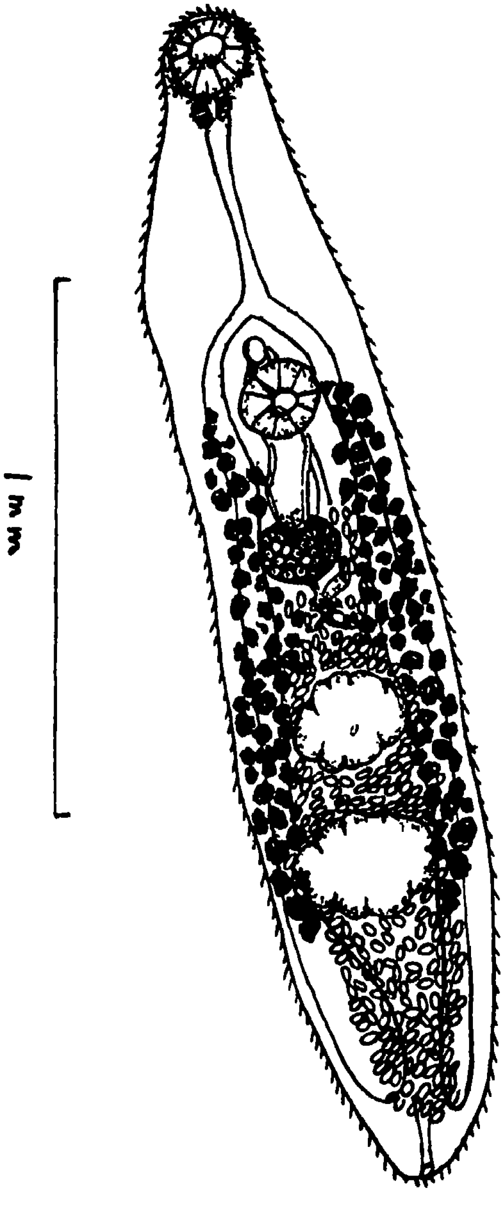

Fig 1
Ventral view of *Astiotrema dassia*

The mouth is an oval opening at the anterior end of the alimentary canal It leads into a muscular pharynx 0 05 mm long by 0 06 mm broad Posterior to the pharynx is a long œsophagus 0 31 mm long by 0 03 mm broad, the latter bifurcates into two intestinal cæca which run up to the posterior end of the body

The excretory pore is terminal and is situated at the posterior end of the body It leads into a Y-shaped excretory bladder which extends up to the ootype, where it branches into two short diverticula

The genital opening is situated in front of the acetabulum a little to the right.

The male reproductive organs consist of two testes with irregular margin giving it a lobed appearance They lie one behind the other in the posterior half of the body The anterior testis is smaller than the posterior and is 0 16 mm long by 0 2 mm broad It lies at a distance of 1 25 mm from the anterior end The posterior testis is 0 2 mm long by 0 25 mm broad It is situated at a distance of 1 5 mm from the anterior end

The cirrus sac is large and extends as far as the ovary It is 0 32 mm long by 0 08 mm broad The seminal vesicle is large and occupies a greater portion of the cirrus sac It is 0 22 mm long by 0 065 mm broad It opens through a short ejaculatory duct into a long narrow cirrus 0 07 mm long The latter opens at the genital pore in front of the acetabulum

The ovary is an oval organ lying at a distance of 0 95 mm from the anterior end It is 0 13 mm long by 0 15 mm broad From the hinder end of the ovary arises the oviduct which opens into the ootype A large number of unicellular shell glands surround the ootype

The receptaculum seminis is a small pear-shaped organ situated on the left side of the ootype It is 0 07 mm long by 0 045 mm broad A Laurer's canal is present.

The vitelline glands consist of small follicles mainly on the lateral sides but cover the intestinal cæca and at places extend into the inter-cæcal area They extend from the ventral sucker to the hinder region of the posterior testis The two transverse vitelline ducts formed by the union of other ducts meet behind the ootype to form a common duct. The latter runs forward to open into the öotype

The uterus arises from the left side of the öotype opposite the opening of the oviduct and runs posteriorly in a sinuous course towards the posterior end It then passes anteriorly in the same manner, to the left of the cirrus sac, and opens into the genital pore

The eggs are oval in shape covered over by a thin brown shell They measure 0 026—0 029 mm in length by 0 012—0 014 mm in breadth

The characters of the new form may be summarised as follows —

Small cylindrical body covered with small spines, oral sucker equal to acetabulum, prepharynx absent, œsophagus long, testes slightly lobed, situated in the posterior half of the body one behind the other, cirrus sac large and extending up to the ovary, receptaculum seminis small, vitelline glands extending from the ventral sucker to the posterior end of the hinder testis

Remarks —The new form, *Astiotrema dassia*, resembles *A indica* Thapar (1933) in having both the suckers equal but differs from it in the absence of prepharynx, in the shape and position of testes, in the extension of vitelline glands and in the shape and size of the receptaculum seminis

KEY TO THE SPECIES OF THE GENUS ASTIOTREMA LOOSS

1 Oral sucker equal to ventral sucker 2

Oral sucker smaller than ventral sucker 3

Oral sucker larger than ventral sucker 4

2 Receptaculum seminis larger than ovary, semilunar in shape Vitelline glands extend from the ventral sucker to the anterior end of the posterior testis *A indica*

Receptaculum seminis much smaller than ovary and pear-shaped Vitelline glands extend from the ventral sucker to the posterior end of the posterior testis *A dassia*

3 Testes rounded, margins smooth vitelline glands from the ventral sucker to the hinder end of the anterior testis *A spinosa*

Testes rounded, vitelline glands mainly extracaecal from a little behind acetabulum to near caecal ends, leaving the latter uncovered *A orientale*

Testes deeply lobed, vitellaria from the ovary to the hinder region of the posterior testis where they extend beyond it *A loossi*

4 Intestinal bifurcation posterior to ventral sucker, intestinal caeca terminate anterior to posterior testis, vitelline glands few *A monticelli*

Intestinal bifurcation anterior to ventral sucker 5

5 Vitelline follicles confluent medially anterior to acetabulum, testes and ovary rounded and about equal in size *A emydis*

Vitelline follicles not confluent anterior to acetabulum, testes distinctly larger than ovary 6

6 Testes rounded with smooth margins 7

Testes lobed 9

7 Intestinal bifurcation behind genital pore, vitelline glands from the middle of oesophagus to the middle of anterior testis *A impletum*

Intestinal bifurcation in front of genital pore 8

8 Testes kidney-shaped, vitelline glands extend from the ventral sucker to the anterior testis, ovary near the middle of the body *A reniferum*

Testes rounded, vitelline glands extend from the ventral sucker to the anterior region of the posterior testis, ovary near acetabulum *A rami*

9 Testes not deeply lobed, intestinal cæca extending behind posterior testis *A elongatum*

Testes deeply lobed, intestinal caeca not extending behind the posterior testis *A. odhneri*

I am deeply indebted to Dr G S Thapar for his kind help and placing at my disposal his valuable library

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ON THE OCCURRENCE OF *SKRJABINEMA OVIS* (SKRJABIN, 1915) IN INDIA

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Communicated by Dr. H. R. Mehra

Received March 8, 1938

SUMMARY

1. ***Skrjabinema ovis*** (Skrjabin) has been recorded as occurring in a fat tailed sheep born and reared at the Allahdad Grantee Farm, Jahania (Punjab), for the first time in India.

2. Previous work on this species has been referred to and its geographical distribution and host list given.

In August, 1937, the author had an opportunity of examining two living pinworms which had been passed out in a speck of mucus by a sheep suffering from diarrhoea, at Jahania (Punjab). On examination both were found to be females of *Skrjabinema ovis* (Skrjabin, 1915).

This parasite was first described by Skrjabin[7] (1915) from sheep in Turkestan. His material also consisted of females, and, on this account he was only able to assign his species to the genus *Oxyuris*. Later, Wereschtschagin[10] (1926), who found both male and female of the species in a collection of goat parasites from Turkestan, created the new genus *Skrjabinema* for this parasite. From the same locality its occurrence in a wild host (*Gazella subgutturosa*) was reported by Schulz[5] (1928). Outside Turkestan, Schwartz[6] (192[illegible]) reported the occurrence of this pinworm in goats in the United States, Morgan[4] (1930) in the British, and Böhm and Gebauer[2] (1930) in the Austrian goats. Mönnig[3] (1932) found this species in another host, the South African Steenbuck (*Rhaphiceros campestris*). Recently, it has been pointed out by Swales[9] (1934) that *Skrjabinema tarandi* which had been described from the Arctic Reindeer (*Rangifer tarandus*) by Skrjabin and Mizkewitsch[8] (1930), is identical to *Skrjabinema ovis*. Schwartz[6], Morgan[4] and Mönnig[3] as well as the original Russian workers have contributed to our knowledge of the morphology of this worm. Hitherto this species has not been recorded from India.

The two female worms at the writer's disposal were carefully studied and compared with the description of the Russian material as quoted by Baylis[1] (1929), and of the British specimens as described by Morgan[4] (1930). The writings of

Schwartz[6] and of the original Russian workers were, unfortunately, not available to the writer A reference to Table I will show that the Indian specimens of this species are in conformity with the Russian and British specimens, in all important measurements The eggs are, however, slightly smaller but the writer does not consider it to be a difference of a specific nature

Table I

(All measurements in millimeters)

	Russian specimens (After Baylis, 1929)	British specimens (After Morgan, 1930)	Indian specimens
Length	6.8—7.64	6.37—7.16	6.09
Breadth, vulvar region			0.34
Breadth, head		0.08	0.084
Excretory pore, distance from anterior end		1.49	1.48
Nerve ring, distance from anterior end			0.18
Oesophagus, total length	0.54—0.77	0.60	0.74
Oesophageal bulb diameter	0.17—0.24	0.15	0.16
Vulva, from head end	2.0—2.24	2.34	1.95
Tail	0.9—1.17	0.88	0.88
Lateral alae, end from posterior extremity		0.5	0.48
Eggs, length	0.054—0.057	0.058—0.063	0.043—0.053
Eggs, breadth	0.032—0.034	0.03—0.031	0.026—0.029
Vagina, length		0.22	0.25

The one year old fat-tailed sheep (Punj *Dumba*) from which the material had been collected belonged to the Allahdad Grantee Farm, Jahania (Punjab) The animal had been reared in a flock of sheep indigenous to the locality, which had not had any contact with imported or foreign sheep in the past It is therefore probable that the infection is of a long standing in the locality Indeed, it is possible that it may have been introduced into this country from Turkestan, before the nineteenth century when there was much traffic in livestock between Central Asia and India.

It will be seen that previously this parasite had not been recorded from its type host (sheep) outside Turkestan Perhaps a careful search in goats and wild ruminants will reveal a wider distribution of this parasite in Indian hosts Diarrhœa and other symptoms in the host animal at Jahania were, in the opinion of the writer, too severe to be attributable to the presence of this parasite

The author takes this opportunity of tendering his grateful thanks to Khan Sahib Prof Karam Ellahie, Professor of Parasitology, Punjab Veterinary College, Lahore, for his encouragement and the facilities kindly provided by him for work in his laboratory

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STUDIES ON THE EFFECT OF ALCOHOL ON THE RESPIRATORY RATE OF LEAVES

By U N Chatterji

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Received April 28, 1938

SUMMARY

Experiments were carried on with a view to find out the effect of alcohol on respiration Definite percentages of ethyl alcohol were introduced into the leaves of *Eugenia jambolana*, the amounts of alcohol thus entering the leaves have been ascertained The subsequent accelaration of the respiratory rate has been compared with the amount of alcohol entering the leaves The accelaration of respiratory rate produced by alcohol decreases with time The percentage of alcohol that brings about the maximum accelaration of the respiratory rate at the beginning does not maintain the increased production of carbondioxide but subsequently brings about a rapid fall On the other hand the alcohol solutions that produce milder stimulation maintain the enhanced respiratory rate for a much longer time.

INTRODUCTION

It has been reported by various authors that anaesthetics affect the respiratory rate of plants Thus Ewart[4] and Zaleski[18] among the earlier workers found that respiratory rate increase by the application of certain anaesthetics. According to Kostychev[13] respiratory carbondioxide production is more accelarated by fermented sugar solutions than by unfermented ones Irving[10] and Thoday[16] report that very small doses of chloroform enhance the respiratory rate of certain leaves More or less similar results have been reported by Thomas[17], Gustafson[7], Irwin[11], Haas[8], Ray[14], Smith[15] and Karlsen[12] The general conclusion is that minute doses of certain anaesthetics stimulate the production of respiratory carbondioxide while stronger doses retard it.

It must be noted however that in all the investigations mentioned above the anaesthetic has not been in any way introduced into the plant materials worked with, they have rather been exposed to an atmosphere containing the anaesthetising material or have been floated on solutions of the anaesthetic By such methods some amount of the chemical substance employed no doubt enters the plant material worked with, but there is no knowing as to how much has actually gone in A measure of the anaesthetising substance actually entering the plant is important rather than the dose exteriorly applied The response due to an anaesthetic can be correlated with the amount of the anaesthetic that actually goes in when that amount is known In this paper the effect of different doses of alcohol on respiration has been studied from this point of view

MATERIAL AND METHOD

The plant material used in this work were leaves of *Eugenia jambolana*. Mature green leaves, as distinguished from the red young ones, were chosen for this work. With some experience and with the help of the position they occupy on trees it was not difficult to distinguish these leaves from the older leaves. It was thus ensured that the leaves selected were more or less similar in age.

The amount of carbondioxide given out has been taken as a measure of respiration. This was measured by variation in the strength of barium hydroxide solution, contained in a series of Pettenkoffer tubes, after the respiratory current had passed through it. Blackman's air commutator was used to transfer the respiratory current from one tube to another after an interval of three hours. The thermostat bath in which the leaf-chambers were kept was maintained at 35°C. This method of carbondioxide estimation is quite well-known and need not be described in detail.

The alcohol used in this work was ethyl alcohol (CH_3CH_2OH, E. Merck) and wherever in this paper the word alcohol is used, ethyl alcohol is meant. The different percentages of alcohol were prepared by volume and all calculations have been done on the basis of fresh weight of leaves.

The actual procedure was as follows:—The leaves were brought and their lamina washed with potassium permanganate solution and sterilised distilled water, they were then kept for several hours. After this they were divided into two sets and the air respiration of both the sets was measured for 24 hours. The first carbondioxide estimation was rejected. If there was any great difference in the respiratory rates of the two sets, the leaves were rejected and a fresh experiment started. After this interval of time the leaves were taken out and one set was injected with distilled water and the other with alcohol solution. By weighing before and after the injection the weights of water or alcohol entering the leaves by injection were determined. The leaves were then replaced in the chambers, the first carbondioxide estimation after injections was also rejected. Injection was carried out by means of a vacuum pump. The leaves were put in a large test tube filled with water or alcohol solution as desired, the tube was connected with the pump which was then worked. On releasing the pressure after some time the leaves got injected with the liquid in which they were kept. The time taken for injecting the leaves and putting them back again was never more than 10 minutes. The end of 24 hours may therefore be taken as the zero hour of alcohol or water injection.

EXPERIMENTAL RESULTS AND DISCUSSION

The experimental results are summarised in the table I. In the case of water-injected leaves, instead of carbondioxide values in separate cases, an average respiratory rate has been given in the table for comparison. Carbondioxide values of air respiration have also been given to indicate the respiratory rate in air.

Table I

Mgms of CO$_2$ per 10 gms of leaves																
	Before injection								After injection							
Hours	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	27-30	30-33	33-36	36-39	39-42	42-45	45-48	48-51
Treatment																
Air	20.9	21.8	20.0	17.4	16.2	14.9	15.1	15.0	15.0	15.2	15.6	15.0	14.4	14.6	14.4	14.4
Water	21.1	22.3	19.5	18.0	16.7	16.0	16.4	Injected here	17.2	15.4	15.0	15.0	14.6	14.4	14.2	14.4
2 % alcohol	20.8	22.6	20.0	18.6	17.1	17.1	16.6		18.2	17.2	16.8	15.5	14.8	15.0	14.8	14.8
3 % "	21.4	22.6	20.4	18.2	18.2	17.2	16.2		19.2	19.6	17.5	18.2	16.2	15.0	14.8	14.8
4 % "	20.1	22.0	19.2	19.5	18.1	17.5	17.1		19.8	19.8	18.2	18.8	16.2	15.6	16.0	14.8
5 % "	20.8	22.6	20.1	18.7	18.2	18.2	17.0		20.6	19.6	20.2	18.7	18.2	17.4	17.8	15.4
6 % "	22.6	21.4	20.2	19.3	18.2	16.8	17.4		20.2	20.6	18.2	17.0	17.8	16.8	17.0	15.0
8 % "	21.0	22.2	20.3	19.4	17.1	17.1	16.4		21.4	18.5	18.8	16.6	14.6	16.5	15.5	15.5
10 % "	22.2	21.5	20.0	18.0	17.0	17.0	15.2		23.0	14.0	16.5	14.0	13.8	14.0	13.6	13.0
15 % "	20.0	21.9	19.5	19.6	17.7	16.0	16.0		10.6	8.2	9.2	10.8	10.0	10.4	9.4	10.0
20 % "	22.8	22.9	20.6	18.4	18.2	15.8	15.8		6.2	9.6	7.6	8.2	5.2	6.5	5.6	5.2
25 % "	22.3	21.5	21.8	18.4	17.2	16.7	15.6		6.3	7.2	4.8	7.6	6.6	5.0	6.3	5.2

It will be seen from table I that respiration of excised leaves begins at a high rate and then falls with time before finding a more or less level phase. The level phase of respiration after the fall seems to be the normal respiratory rate in darkness. It is necessary to examine the rate of respiration as affected by the injection of distilled water and to compare it with the normal respiratory rate in air, water-injected leaves were used to serve as controls for alcohol-injected leaves—the relation between the respiratory rate of alcohol-injected leaves and that of uninjected ones can therefore be easily deduced. It must be mentioned here that by injection the intercellular spaces of leaves got filled up with either water or alcohol-solution. And, till the liquid in the intercellular spaces diffused into the adjoining cells, the leaves were subjected, partly at least, to a condition of temporary anaerobiosis. As has been said, about three hours were allowed to pass before any carbondioxide estimation after injections was taken into account. It was assumed that this interval of time was sufficient to restore the aerobic condition but no attempt was made to determine whether this was actually so. It is also evident from Table I that *water-injection causes a temporary rise in the respiratory* rate of leaves—the rate being not only higher than the leaves respiring normally in air but also higher than that before injection. Several authors[2,5,11,18] have reported increase in respiratory rate by water. The increased rate of carbondioxide production may also be partly due to the inevitable handling of leaves during the injection operations, *Godwin*[6], *Audus*[1] *and Baker*[3] *report that handling acts* as a mechanical stimulus in increasing respiration. Whatever be the cause or causes, increased carbondioxide production of water-injected leaves does not continue for a long time and, after 6-9 hours after injection, the respiration of injected and uninjected leaves are almost equal. It will not be a mistake therefore if, except *for* this short-lived stimulation, the *respiratory* rate of water-injected leaves be taken to represent the normal rate of respiration in air.

Amount of alcohol entering the leaves.—Before considering the effect of alcohol on respiration it will be advantageous to know what amount of alcohol enter the leaves by injection. The amount of alcohol solution entering the leaves by injection was found out in each case as has already been said; from this the weight of alcohol introduced has been calculated as shown in Table II. Aquous solutions of alcohol were injected into the leaves. Therefore in order to get the true effect of alcohol on respiration any stimulation brought about by water alone will have to be subtracted from the combined effect of the two. In this connection it will be recalled that the effect of water-injection, although afterwards quite negligible, is most felt about 3-6 hours after injection, a period which synchronises with the maximum stimulation produced by alcohol solution. The data obtained by subtracting the effect of water in each experiment from the effect of aquous solution of alcohol (3-6 hours after injection) have been plotted in Fig 1 in which the amounts of alcohol entering the leaves have also been shown It will be seen that carbondioxide production is accelarated by alcohol accumulation within the leaves upto a certain extent and then falls with the increasing concentration and amount of alcohol The maximum output obtained seems to be somewhere near 10 % alcohol

Table II

Alcohol injected	Mgms of alcohol entering the leaves (per 10 gms)
2%	55 3
3%	94 8
4%	101 1
5%	130 3
6%	151 6
8%	189 6
10%	237 0
15%	367 3

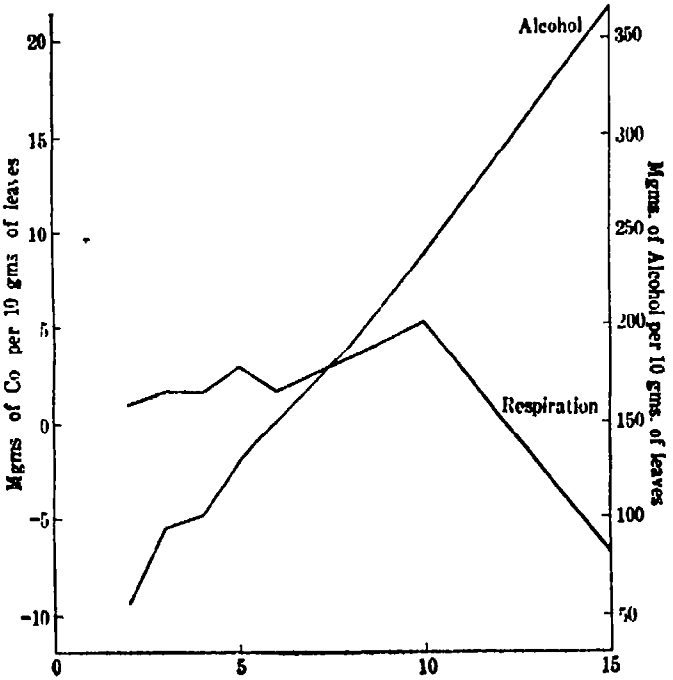

Fig 1
The amount of alcohol entering the leaves and the respiratory rate

It will be easy to compare the rates as affected by different percentages of alcohol and water with that of normal air respiration if all the relevant data could be plotted on a single graph and the smoothed-out curves shown This has been done in Fig 2 in which the curves represent the respiratory rate in air and respiratory rates as affected by water and different alcohol solutions The stimulation of carbon-dioxide production, as is evident from this figure, increases with increasing concentration of alcohol The accelaration however dies down with time and after 24 hours after injection the carbondioxide production falls to about the normal level

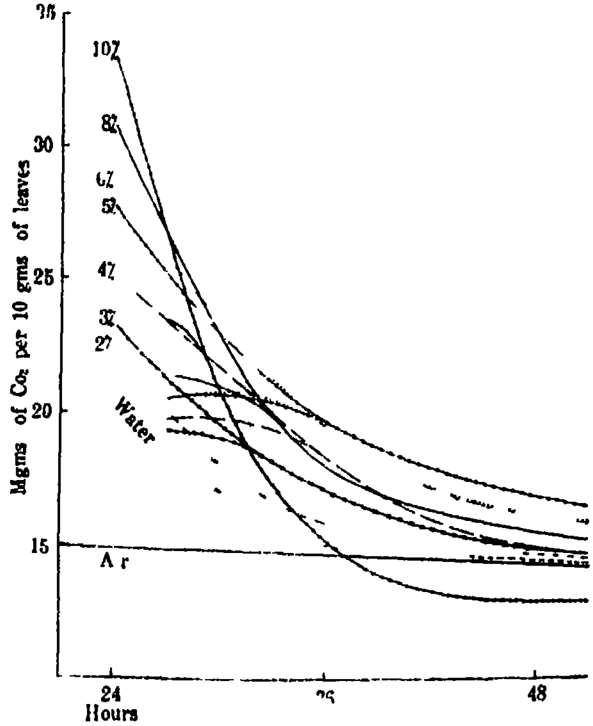

Fig 2
The effect of different percentages of alcohol

The carbondioxide estimations were begun after several hours after injection, when, it is natural to suppose, the effect of the stimulus supplied had probably been to some extent modified But theoretical values at zero hour of injection can be obtained by extrapolating the curves to the time when normal carbondioxide measurement was stopped as shown in Fig 2 In Table III are given the experimental and derived carbondioxide values as enhanced by water-injection

Table III

CO$_2$ of normally respiring leaves (Exp)	CO$_2$ of leaves injected with water (Exp)	CO$_2$ of leaves injected with water (derived)	Accelaration by water	
			Experimental value	Derived value
15 mgms	17 2 mgms.	21 3 mgms	2 2 mgms	6 3 mgms

In Table IV are compared the first carbondioxide values after alcohol injections with those obtained by extrapolating the curves The derived values in the majority of cases, stand much higher than those experimentally obtained, suggesting that the acceleration would probably be much greater at zero hour after the application of the stimulus

Table IV

Alcohol injected	CO$_2$ of leaves injected with water (Exp)	CO$_2$ of leaves injected with Alcohol (Exp)	CO$_2$ of leaves injected with water (derived)	CO$_2$ of leaves injected with alcohol (derived)	Accelaration by alcohol	
					Experimental value	Derived value
2%	17 2 mgms	18 2 mgms	21 3 mgms	22 3 mgms	1 mgms	1 mgms
3%	" "	19 2 "	" "	23 3 "	2 "	2 "
4%	" "	19 8 "	" "	25 0 "	2 6 "	3 7 "
5%	" "	20 6 "	" "	27 6 "	3 4 "	6 3 "
6%	" "	20 2	" "	28 5 "	3 0 "	7 2 "
8%	" "	21 4 "	" "	30 7 "	4 2 "	9 4 "
10%	" "	23 0 "	" "	34 5 "	5 8 "	13 2 "

The percentage increase of carbondioxide production over the normal respiratory rate (Table III) by different concentrations of alcohol is shown in Table V—the percentages are calculated both from increases experimentally obtained as well as from data derived by extrapolating the curves

Table V

Alcohol injected	Percentage increase obtained experimentally	Percentage increase from derived value
2%	6 7	6 7
3%	13 3	13 3
4%	17 3	24 7
5%	22 7	42 0
6%	20 0	48 0
8%	28 0	62'7
10%	32 0	88'0

Duration of increased carbondioxide production —It has been pointed out that the stimulation of carbondioxide production by alcohol decreases with time This has been clearly shown in Fig 3 If the interval of time between 3-6 after injection is taken into consideration the stimulation of carbondioxide production increases as the concentration of alcohol increases, the highest stimulation being obtained with a 10 % solution But if a period of time twelve hours after injection is considered it is evident that the earstwhile maximum stimulant has yielded place to a solution containing a lesser amount of alcohol, the greatest stimulation being obtained with 4-5 percent alcohol After 24 hours after injection the stimulation almost dies down Thus the maximum stimulant (10% alcohol) at the beginning does not maintain the increased production of carbondioxide but actually brings about a rapid fall, reducing the carbondioxide production to a level below that of the normal air respiration On the other hand milder percentages of alcohol maintain enhanced rate for a much longer time

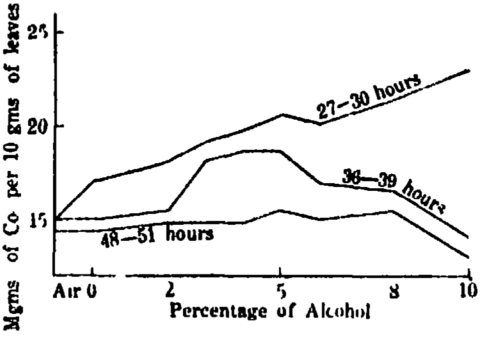

Fig 3
Effect of alcohol as related to time

Total carbondioxide production after injection —The period during which carbondioxide was estimated after injection was 24 hours. The total amount of carbondioxide evolved during this time by alcohol-injected leaves may be compared with the average carbondioxide value of leaves injected with water and that of the uninjected leaves during the same time (Fig 4) In this way the alcohol solution that produces the highest stimulation when a larger interval of time is considered is found to be a 5 percent one

Ratio of total carbondioxide production —The respiratory rates of two sets of leaves—the experimental and the control—were never exactly the same even before injection, although they were very nearly equal Therefore if the ratios of carbondioxide values of the two sets are known before and after the stimulus is applied then the comparison of the two ratios obtained will be the most correct method of appraising the effects of the stimulus The control throughout has been water-injected leaves and the very temporary nature of the stimulation produced by water injection has already been alluded to, after this brief rise the respiratory rate returns to that normally obtaining in air. If the carbondioxide values before and after the water injection be plotted on a graph and the two portions of the curve (before and after the injection) be joined so as to neglect the temporary rise, the possible carbondioxide values for normal air respiration may be obtained. The carbondioxide values of air respiration for the equivalent period during which those of different alcohol-injected leaves were estimated are thus obtained and the ratio can therefore be calculated. The ratios before and after the injections are compared in table VI.

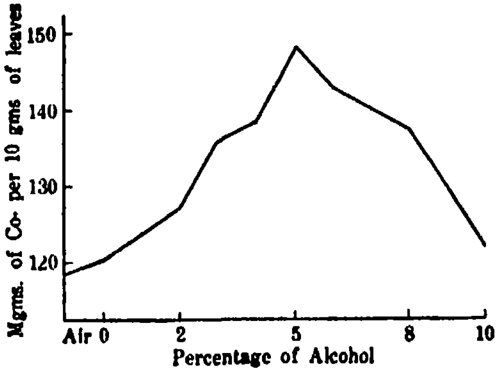

Fig 4

Total carbondioxide production for 24 hours

Table VI

Alcohol injected	Before injection			After injection		
	CO_2 values of control set in mgms	CO_2 values of experimental set in mgms	Ratio $\frac{CO_2 \text{ experimental}}{CO_2 \text{ control}}$	CO_2 values of control set in mgms	CO_2 values of alcohol set in mgms	Ratio $\frac{CO_2 \text{ alcohol}}{CO_2 \text{ control}}$
2 %	131·9	132·8	1·00	118·7	127·1	1·07
3 %	135·1	134·2	·99	118·1	135·3	1·15
4 %	135·5	133·5	·99	121·8	139·2	1·14
5 %	131·8	133·6	1·02	123·8	147·9	1·19
6 %	134·2	135·9	1·01	121·3	142·6	1·18
8 %	131·9	133·5	1·01	122·2	137·4	1·13
10 %	131·9	130·9	·99	121·5	121·9	1·00
15 %	132·9	130·7	·99	123·2	78·6	·64
20 %	134·5	135·2	·99	123·5	54·1	·44
25 %	133·2	133·5	1·00	125·4	49·0	·39

If the different values of $\frac{CO_2 \text{ experimental}}{CO_2 \text{ control}}$ of the above table be reduced to unity and the corresponding values of $\frac{CO_2 \text{ alcohol}}{CO_2 \text{ control}}$ be calculated then all the values of $\frac{CO_2 \text{ alcohol}}{CO_2 \text{ control}}$ become directly comparable. Table VII gives the values calculated in this way.

Table VII

Alcohol injected	Before injection	After injection
	$\frac{CO_2 \text{ experimental}}{CO_2 \text{ control}}$	$\frac{CO_2 \text{ alcohol}}{CO_2 \text{ control}}$
2 %	1	1.07
3 %	1	1.16
4 %	1	1.15
5 %	1	1.17
6 %	1	1.17
8 %	1	1.12
10 %	1	1.01
15 %	1	.65
20 %	1	.44
25 %	1	.39

Thus the effect of alcohol in stimulating the respiratory rate increases with the increasing concentration of alcohol, the limit being reached with 5%-6% solutions. Beyond these strengths the production of carbondioxide progressively diminishes with increasing concentration of alcohol, the output falling with more concentrated solutions to lower than that of the normal respiration.

The author thanks Dr. S Ranjan for helpful criticism and guidance,

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COLOUR AND CHEMICAL CONSTITUTION THE ORGANIC AND INORGANIC SALTS OF DIPHENYLVIOLURIC ACID

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SUMMARY

1 A large number of organic and inorganic salts of diphenylvioluric acid have been prepared for the first time with a view to find out a relationship between the colour and chemical constitution of these substances

2 Diphenylvioluric acid has got a pale yellow colour in the solid state and in solution in non hydroxylic organic solvents, but on treatment with alkalies or organic bases intense violet coloured salts are formed, the transition of colour being sufficiently sharp and strong for it to act as a first-class indicator

3 The change of colour from pale yellow to purple has been shown to be due to a fundamental change in the constitution of the molecule from an oximino-ketonic to a nitroso-enolic structure.

4 The above change in the molecular structure results in the production of a nitroso group which, from the point of view of the theory of colour on the basis of molecular strain advanced by one of the present authors, has been shown to be the most highly strained amongst the chromophoric groups and consequently produces the greatest intensity of colour

5 The loading effect of the phenyl groups on violuric acid has been discussed and it has been shown that the effect is quite in accordance with the theory of colour already advanced by Dutt

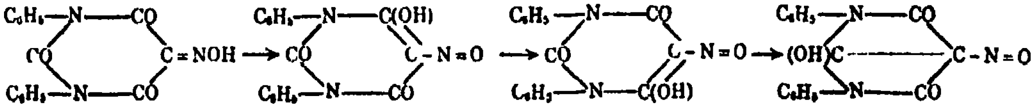
6 From a study of the absorption spectra and hydrolysis constants of the organic and inorganic salts of diphenylvioluric acid it has been shown that the intensity of the colour of the salts is roughly proportional to the strength of the basic character of the base, as previously found in the case of the corresponding salts of violuric acid in this laboratory although no hard and fast mathematical relationship could be established between the two sets of properties

7 Further study of the absorption spectra of the salts of newly synthesised higher homologues and analogues of diphenylvioluric acid indicates that the effect of additional load on the molecule of the substance is to produce still further intensification of colour as expected from theoretical considerations, the greatest effect being produced by substituents in the meta position closely followed by those in the para.

Violuric acid and its highly coloured organic and inorganic salts have been investigated, from the point of view of colour with relation to chemical constitution, by a large number of workers, but the corresponding diphenylviolurates and also the di-meta-tolyl and di-para-tolyl derivatives have been quite unknown. The authors have prepared these derivatives for the first time and the present paper is an outcome of their attempt to study the phenomenon of colour in these compounds with relation to their chemical constitution.

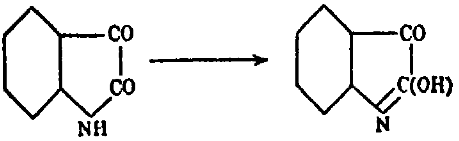
Hantzsch, Meek and Watson have shown that the colour of alkali violurates in aqueous solution is mainly due to the dissociation of these substances into ions and the stronger the base, the greater is the colour development. The present investigations on diphenylviolurates reveal that although in general the previous conclusion of the former workers, namely, the stronger the base, the greater the absorption, still holds in the case of the salts of diphenylvioluric acid, yet there is no definite mathematical relationship between absorption spectra and dissociation constants of these compounds. It has also been found out in the present investigations that the highly coloured nature of diphenylviolurates is not due to their dissociation into ions, for the salts derived from very weak organic bases like aniline, pyridine, etc., some of which have the basicity constants of the order 10^{-11}, mentioned in the present paper, have colours no less intense than the alkali diphenylviolurates whose dissociation constants are fairly high, being of the order 1.263×10^{-2}—2.065×10^{-2}.

Having ruled out the possibility of molecular ionisation, we find that the most reasonable explanation of the origin of colour in these compounds lies in a change of constitution of the molecule. When the faint pink colour of the aqueous solution of diphenylvioluric acid changes to intense crimson on the addition of alkali, there must take place a fundamental change in the constitution of the molecule, whereby it is rendered capable of far greater absorption of energy due to a more strained molecular structure. From the point of view of the theory of colour on the basis of molecular strain, advanced by Dutt,[1, 2] the alterations of the molecular configurations of diphenylvioluric acid may be represented as follows:—

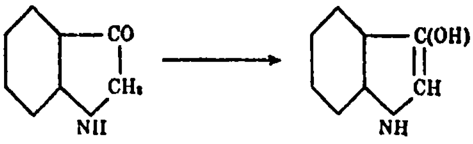


(1) (2) (3) (4)

Out of these configurations, structures Nos. (2), (3), and (4) contain the highly strained N=O group which is capable of very intense colour production, and in view of the deep colour of diphenylviolurates, it is but natural to conclude that this group must be present in these substances. This point of view is rendered more feasible when we consider that in diphenylvioluric acid the three carbonyl groups that are present, are in reality the residues of carboxyl groups, and being in this way quite devoid of ketonic properties, possess dormant acidic functions, which are clearly manifested whenever there are chances of salt formation with bases By the migration of a labile hydrogen atom, the (CO) group becomes a highly acidic group —C(OH), perfectly capable of forming well-defined salts as can be seen in the case of isatin and indoxyl

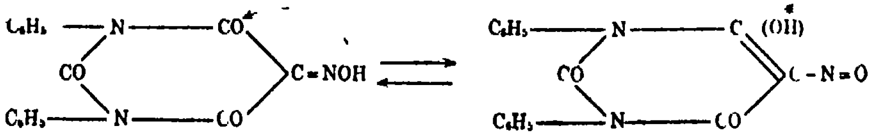


Isatin



Indoxyl

In the above configurations, the change of structure (1) into structure (4) is somewhat far fetched in view of the fact that an easier path is available for the hydrogen atom of the isonitroso group to enolise with an adjacent carbonyl group Hence under such circumstances the interesting colour phenomenon displayed by diphenylvioluric acid and its salts is positively due to the migration of a hydrogen atom to the (CO) group with the production of a stronger acid than could be expected from the oximino-ketonic configuration



Oximino-ketonic form
(Weak acid like all oximes)

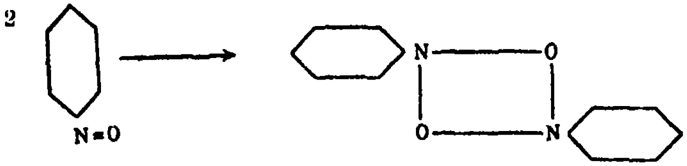
Nitroso-enolic form (Strong acid like alloxantin and uric acid)

The function of the salt formation is to fix up the nitroso enolic form, so as to end the tautomeric migration of the hydrogen atom from one position to another and once the nitroso structure is fixed up by the heavy load of the substituent metal or organic basic radical, the tautomerism from one form to the other is not so easy and the more highly strained nitroso-enolic form becomes stable and the full colour that is expected from such a highly strained configuration, as the nitroso group, becomes established

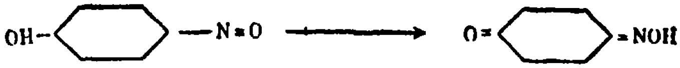
We can arrive at this conclusion by a different route too According to the "theory of colour on the basis of molecular strain", the combination of a nitrogen with an oxygen atom by double bonds is the most highly strained system, for the distortion suffered by the valencies from the theoretical considerations is three hundred degrees, which is far in excess of all other combinations (Dutt[1,2]) The idea is clearly manifested in the remarkable instability of the compounds containing this grouping This high strain in the molecule of nitroso compounds produces intense colour and makes them highly absorptive, *e g*,

		Absorption maxima	Colour
1	Nitrosobenzene	7300	Green
2	P-nitrosotoluene	7300	„
3	Nitrosomesitylene	7320	„
4	T-nitrosobutane	6390	Blue
5	P-nitrosoisopropylacetone	6600	„

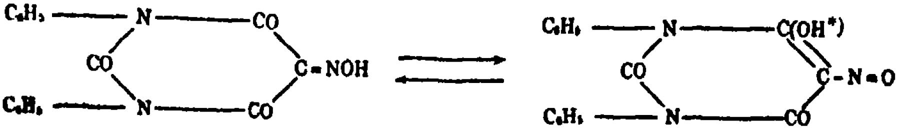
Due to a high strain in the molecule most of the nitroso compounds tend to lose their internal strain by the formation of bimolecular compounds,



But if the nitroso group is in a molecule containing a labile hydrogen atom, it automatically rearranges itself to a condition of less strain by the formation of isonitroso or oximino compounds, thus nitroso phenol changes into benzoquinone-mono-oxime



It is on account of this change into the less strained oximino compound that most of the nitroso compounds do not exhibit the deep colours that are theoretically expected from them This applies equally well to the particular case of diphenylvioluric acid, which in the solid state is pale yellow But under special circumstances it is possible sometimes to stabilise the nitroso-enolic form and in such cases the nitroso group exhibits its true nature and gives deep coloured salts. When diphenylvioluric acid is treated with alkali, the marked hydrogen* atom of the tautomeric nitroso-enolic form is replaced



Oximino-ketonic form
(Pale yellow)

Nitroso-enolic form
(Violet)

by a metal and the nitroso form gets stabilised The result of all this is that the nitroso group (—N=O) gets a chance to show its true nature and consequently highly coloured salts are produced

Diphenylvioluric acid also possesses another interest from a different standpoint, and that is from the point of view of loading of the violuric acid molecule with two phenyl groups and the consequent effect on colours It is a well known phenomena in colour chemistry that quite a large number of dyestuffs become intensified in colour whenever their molecules are loaded

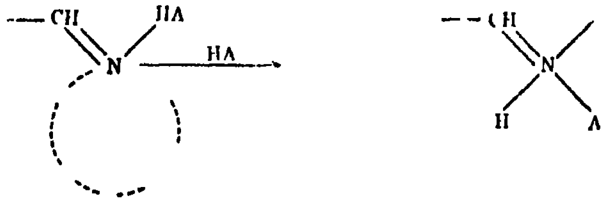
The expectation from the theoretical point of view has been realised in the case of salts derived from diphenylvioluric acid and they are in fact found to have higher absorption maxima than the corresponding salts of violuric acid With still further substitutions, *i e*, salts obtained from meta and para-di-tolyl violuric acid, which have been synthesised for the first time by the authors, show even greater intensity of colour and higher absorption maxima than corresponding derivatives of diphenylvioluric acid, as can be seen from the following table —

Table I

Name of the salt	Violuric acid	Diphenyl violuric acid	Di-P-Tolyl violuric acid	Di-M-Tolyl violuric acid
1 Ammonium	5832 Å	5845 Å	5860 Å	5880 Å
2 Methylamine	5782 ,,	5810 ,,	5835 ,,	5880 ,,
3 Trimethylamine	5712 ,,	5765 ,,	5807	
4 Ethylamine	5691 ,,	5785 ,,	5805 ,,	5845 ,,
5 Diethylamine	5699 ,,	5875 ,,	5900 ,,	
6 Pyridine	5692 ,,	5825 ,,	5850 ,,	5865 ,,
7 Picoline	5692 ,,	5810 ,,	5880 ,,	5848 ,,

The alkaloidal salts of diphenylvioluric acid show optical rotation like the corresponding compounds of its homologue violuric acid, although their rotation is always less than that of the parent alkaloid It will be interesting to consider this fall in rotation from the point of view of Stewart's[3] work Stewart[3] has shown that greater the unsaturation of a substance, the greater will be its optical rotation and higher its absorption maxima

It is a well known fact that the group—CH=N—present in most of the alkaloids is a negative unsaturated group and as soon as the salt formation takes place, the two latent valencies of the nitrogen atom become manifested, the structure becoming as follows —



Hence if this unsaturation is removed after salt formation the resulting salt should have a less rotatory power than the original alkaloid This has actually been observed in the present investigations In some cases the rotation has decreased so much that even optical inversion has taken place

EXPERIMENTAL

The diphenylbarbituric acid, required for the preparation of diphenylvioluric acid, was prepared by the method devised by Whiteley [4] The diphenylbarbituric acid was then changed into its isonitroso derivatives by dissolving it in a dilute solution of caustic soda in which a slight excess of sodium nitrite had already been dissolved and adding this solution to ice-cold dilute sulphuric acid. The yellow amorphous mass obtained was filtered, dried and crystallised from a mixture of benzene and alcohol (7 1)

The crystals obtained from pure benzene have been found to be isomorphous with those of violuric acid In the pure state diphenylvioluric acid melts with decomposition at 228°C It is soluble in ether, alcohol and hot benzene In hot water it dissolves giving a faint pink solution With copper sulphate solution it gives a yellowish brown colour and with ferric chloride a deep red solution is produced

The preparation of di-para-tolyl and di-meta-tolyl barbituric acid was effected precisely in the same way as of diphenylbarbituric acid The latter melts at 247°C and is white in appearance It is sparingly soluble in water and in alcohol and completely soluble in chloroform and alkalies It also gives a red coloration with ferric chloride The former melts at 157°C and is sparingly soluble in cold alcohol It gives a pale yellow precipitate with silver nitrate solution, the precipitate being soluble in ammonia and reappears on adding dilute nitric acid

The di-para-tolyl and di-meta-tolyl derivatives of violuric acid were prepared in exactly the same way as the diphenyl derivative Both these derivatives are yellow in colour and dissolve in alcohol, ether and benzene, but are completely insoluble in water The alcoholic solution decomposes when it is boiled for some time The di-meta-tolyl violuric acid melts with decomposition at 184°C but the

Table II

Number	Name of the salt	Colour in solid state	Colour in solution	Absorption maxima	Hydrolysis constants	Analytical results showing percentage of nitrogen (theoretical values in brackets)
1	Diphenylvioluric Acid	Pale yellow	Pink	5650 Å	*$10^{-2} \times 6.443$ (42.21 mhos)	13.62% (13.59)
2	Sodium D †	Deep pink	Violet	5835 „	*$10^{-2} \times 1.584$ (57.48 mhos)	12.35% (12.68)
3	Potassium D	Purple violet	Purple violet	5840 „	*$10^{-2} \times 2.065$ (77.71 mhos)	11.76% (12.07)
4	Ammonium D	Deep pink	Violet	5845 „	*$10^{-2} \times 1.263$ (71.91 mhos)	17.06% (17.39)
5	Lithium D	Light orange	Pinkish violet	5792 „		13.51% (13.37)
6	Methylamine D	Pinkish violet.	Violet	5810 „	$10^{-7} \times 3.725$	16.59% (16.47)
7	Dimethylamine D	Bluish violet	„	5805 „	$10^{-7} \times 2.57$	16.01% (15.82)
8	Trimethylamine D	Orange	Pinkish violet.	5765 „	$10^{-8} \times 2.57$	15.03% (15.21)
9	Ethylamine D	Purple red	Violet	5785 „	$10^{-6} \times 3.408$	16.09% (15.81)
10	Diethylamine D	Bluish violet	„	5875 „	$10^{-7} \times 1.51$	14.88% (14.66)
11	Allylamine D	Pink	„	5724 „	$10^{-6} \times 3.348$	15.1% (15.3)
12	Isobutylamine D	Violet		5870	$10^{-7} \times 6.156$	14.61% (14.50)
13	Isoamylamine D	Pink	Bluish violet	5835 „	$10^{-7} \times 3.819$	14.22% (14.14)
14	Aniline D	Pinkish violet	Pink	5725	$10^{-1} \times 4.14$	14.3% (14.14)
15	O-Toluidine D	Reddish pink	Purple violet	5813 „	$10^{-1} \times 5.78$	13.57% (13.46)
16	M-Toluidine D	Purple violet	Violet	5690 „	$10^{-1} \times 3.47$	13.47% (13.46)
17	P-Toluidine D	Pink	„	5810 „	$10^{-1} \times 9.54$	13.63% (13.46)
18	Xylidine D	Violet	Purple violet	5760 „	$10^{-1} \times 3.08$	13.26% (13.02)
19	O-Anisidine D	Purple violet	Violet	5715 „	$10^{-1} \times 10.04$	12.73% (12.96)
20	P-Phenetidine D	„	„	5770 „		12.80% (12.55)
21	O-Phenylene diamine D	Brick red	„	5800 „	$10^{-1} \times 5.78$	17.05% (16.78)
22	P-Phenylene diamine D	„	„	5710 „	$10^{-1} \times 5.78$	16.95% (16.78)
23	∝-Naphthylamine D	Violet	„	5852 „	$10^{-1} \times 19.29$	12.51% (12.38)
24	Pyridine (normal) D	Light orange	Pinkish violet	5825 „	$10^{-2} \times 6.31$	14.45% (14.42)

† D stands for Diphenylviolurate

* The values marked with an asterisk show the dissociation constants of those salts those given in the brackets indicate the molecular conductivity

Table II (Contd)

Number	Name of the salt	Colour in solution	Colour in solution	Absorption maxima	Hydrolysis constants	Analytical results showing percentage of nitrogen (theoretical values in brackets)
25	Pyridine (complex) D	Violet	Violet	5860 Å		15.19% (14.90)
26	Piperidine (complex) D	Rosy pink	„	5670 „		14.84% (14.61)
27	∝-Picoline D (complex)	Violet	„	5810 „		15.03% (14.9)
28	Collidine D (complex)	„		5710 „		12.82% (21.70)
29	Quinoline D	Orange	„	5780 „	$10^{-3} \times 19.08$	12.97% (12.78)
30	Isoquinoline D	Brownish yellow	Purple violet	5783 „	$10^{-1} \times 5.30$	12.61% (12.78)
31	Quinaldine D	Orange	Violet pink	5655 „	$10^{-2} \times 4.77$	12.40% (12.39)

Table III

Number	Name of the salt	Colour in solid state	Colour in solution	Absorption maximum	Rotation of alkaloid at 24°C	Rotation of salt at 24°C	Hydrolysis constant	Analytical results showing percentage of nitrogen (theoretical values in brackets)
1	Nicotine D*	Dark violet	Pink	5650 Å	−161.35	+128.1		15.15% (14.86)
2	Morphine D	Violet	Violet	5823 „	−140.0			9.15% (9.42)
3	Brucine D		Pink	5785 „	−120.0	−45.73		10.21% (9.95)
4	Cinchonidine D	Orange	Violet	5813 „	−113.6		$10^{-4} \times 5.16$	11.74% (11.44)
5	Narcotine D	Violet	„	5760 „	−207.35	+61.22	$10^{-3} \times 2.41$	7.91% (7.75)
6	Quinine D		„	5915 „	−165.1	+96.9	$10^{-4} \times 8.67$	11.31% (11.05)
7	Quinidine D	Blue	„	5795 „	+250.2	−98.15	$10^{-4} \times 7.95$	11.15% (11.05)
8	Codeine D	Violet	Violet pink	5850 „	−132.0	+62.3		8.74% (8.94)

*D stands for Diphenylviolurate

Table IV

Number	Name of the salt	Colour in solid state	Colour in solution	Absorption maxima	Analytical results showing percentage of nitrogen (theoretical values in brackets)
1	Di-m-Tolylvioluric Acid	Pale yellow	Yellow	4600 A	12·59% (12·46)
2	Ammonium D-m-t.*	Purple violet	Purple violet	5880 „	16·03% (15·81)
3	Methylamine „	Dark violet		5880 „	15·03% (15·21)
4	Ethylamine „	Reddish violet	Violet	5845 „	14·85% (14·66)
5	Pyridine „	Orange	Purple violet	5865 „	13·35% (13·46)
6	∝-Picoline „	„	„	5848 „	12·89% (13·02)
7	Di-para-Tolylvioluric Acid	Yellow	Yellow	4650 „	12·62% (12·46)
8	Ammonium D-p-t	Purple violet	Purple violet	5860 „	15·55% (15·81)
9	Methylamine „	Violet		5835 „	15·50% (15·21)
10	Trimethylamine „	Purple violet	„	5807 „	14·35% (14·14)
11	Ethylamine „	Violet	„	5805 „	14·48% (14·66)
12	Diethylamine „	Purple red	Deep pink	5900 „	
13	Pyridine „	Orange	Violet	5850 „	13·5% (13·46)
14	∝-Picoline „	Purple violet	Blood red	5880 „	13·21% (13·02)

* D-m-t stands for Di meta-tolylviolurate and D-p-t stands for Di para-tolylviolurate.

corresponding para compound does not give a sharp melting point and begins to decompose at 160°C

All these violuric acids combine with inorganic alkalies and organic bases giving highly coloured salts the shades of which vary from orange and pink to violet and finally deep blue All these salts were prepared by mixing equimolecular quantities of the acid and the base in alcoholic solution Some of the salts separated out in the form of crystalline precipitates, on allowing the mixture of solutions to stand for a few minutes, while in other cases the solution was evaporated to dryness and the salt obtained was recrystallized Sometimes, specially in the case of alkaloid salts, a sticky mass was obtained on evaporation This was repeatedly rubbed with ether till the whole mass broke down to a fine amorphous powder which was filtered washed with ether and dried

All these salts are insoluble in benzene but dissolve in water or alcohol giving violet solutions Some of them give a sharp melting point while others decompose without melting Most of them are stable under ordinary atmospheric conditions but some of them specially the alkaloidal salts become sticky on exposure to moisture and then decompose

The main properties of the individual salts are given in tabular form in Tables II, III and IV (pp 35-36, 37, 38)

References

1 Dutt (1926) ***Jour Chem Soc***, **129**, 1179
2 „ (1927) ***Jour Ind Chem Soc***, **3**, 99
3 Stewart (1907) ***Jour Chem Soc***, **99**, 209
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CAUSTIC SODA AND ALUMINA FROM SALT AND BAUXITE

(A NEW PROCESS OF MANUFACTURE)

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SUMMARY

The process aims at a new method for the production of pure alumina and caustic soda starting from bauxite, common salt and barytes, the last can however be used cyclically over and over again. By heating bauxite and barytes a soluble barium aluminate is obtained with the evolution of SO_2. On solution and hydrolysis of this barium aluminate pure alumina and barium hydroxide are obtained, while the SO_2 gas is used in converting common salt to sodium sulphate. A final reaction between the barium hydroxide and the sodium sulphate results in the production of sodium hydroxide and barium sulphate which can be used over again.

The manufacture of caustic soda, soda-ash and sulphuric acid constitutes the backbone of the heavy chemical industry as a whole but till now India is dependent on foreign countries for the supply of all these chemicals.

In this country for the development of the electrolytic manufacture of NaOH, localities where very cheap power is available are almost as rare as are the occurrences of sulphur either free or as pyrites, so necessary for making sulphuric acid. It was with the intention of developing a process suitable to Indian raw materials and conditions that this work was undertaken.

Lunge, the celebrated chemical technologist, has remarked that sodium sulphate would be a very suitable compound for manufacturing NaOH by causticization with $Ba(OH)_2$ provided this compound could be manufactured sufficiently cheap. In the light of this remark the possibility of utilizing barytes ($BaSO_4$), useless at present, which occurs abundantly in various places in India, for the purpose of making this $Ba(OH)_2$ and using the SO_2 set free in H_2SO_4 manufacture was considered. After investigation the method found most suited to this end was the conversion of $BaSO_4$ first into barium aluminate and then the hydrolysis of this latter compound into $Ba(OH)_2$ and $Al(OH)_3$.

The essential steps in the process could be outlined as below:

1. Production of barium aluminate from bauxite and barytes at a temperature of 1200°C – 1400°C.

$$2BaSO_4 + 2Al_2O_3 = 2BaO \cdot Al_2O_3 + 2SO_2 + O_2$$

2. Hydrolysis of water soluble barium aluminate
$BaO \cdot Al_2O_3 + 4H_2O = Ba(OH)_2 + 2Al(OH)$

3. Formation of Na_2SO_4 from NaCl and SO_2
$2NaCl + SO_2 + O_2 + H_2O = Na_2SO_4 + 2HCl$

4. Causticization of Na_2SO_4 by $Ba(OH)_2$
$Na_2SO_4 + Ba(OH)_2 = BaSO_4 + 2Na(OH)$

The reactions involved in the last two steps are well known. Step No. 3 gives the conversion of common salt into sodium sulphate by the action of SO_2, oxygen and steam according to Hargreave's process. HCl formed, is recovered as a valuable by-product, which can also be used with pyrolusite to give chlorine and bleaching powder. The SO_2 utilized in this reaction can also be used to manufacture free H_2SO_4 if this acid is desired.

In step No. 4 a 30 % solution of Na_2SO_4 in water is treated with a dilute $Ba(OH)_2$ solution. The insoluble $BaSO_4$ formed is immediately thrown down leaving Na(OH) in solution. This solution can be concentrated to give fused NaOH, or purified CO_2, obtained from the calcination of barytes-bauxite mixtures in which this gas is invariably evolved due to combustion of large amounts of organic matter present in the bauxite, can be passed through it and NaOH converted to Na_2CO_3. The precipitated $BaSO_4$ can be used, again in the first step or for the manufacture of lithophone required in paints.

Thus the success of the process depends on steps Nos. 1 and 2 which have therefore been the subject of investigation in this paper. Particular stress has been laid on the first part, because regarding the second it is already known that of the many aluminates of barium several have a good solubility in water and are of an unstable nature. Recently the problem of making barium aluminate from barytes and bauxite was investigated by Booth and Ward,[1] who critically examined the work of earlier investigators and have drawn some interesting conclusions. However, they have confined their published results to a study of solutions of barium aluminates in hydrochloric acid only. For the present process the formation of $Ba(OH)_2$ is vital for the causticization and in acid solutions this is not possible as $BaCl_2$ is formed. Thus the whole work had to be repeated and conditions determined for the formation of the maximum amount of water soluble barium aluminate.

The experimental procedure followed was as given below :—

Various mixtures of barytes and bauxite were made such that the proportions of BaO and Al_2O_3 in them corresponded very nearly to the relative proportions of these oxides in the different known as well as some hypothetical barium aluminates. These mixtures were then intimately ground in a ball mill to a grain size of below 200 mesh and dried. Some preliminary experiments with coarser powders had shown that the fineness of the grain had a profound effect on the progress of the reaction.

Weighed amounts of the dried mixtures were placed in fire-clay crucibles and heated in a muffle furnace up to temperatures ranging from 1150°C to 1450°C. In all the experiments the temperature was raised with the crucibles inside the muffle, and when the final temperature required was attained, it was maintained at that level for a measured period of time. Then the muffle was allowed to cool, the mixtures taken out of the crucibles and the loss in weight determined. In some cases when firing temperature was high the mass was sintered hard and stuck to the crucible so that weighing was not accurate and measurements only to the nearest tenth of a gram were made. The mixtures were then powdered.

From each of them an accurately weighed amount was taken and repeatedly leached with hot water (the solubility of barium aluminate being more in hot than cold water) till the filtrate coming out was free from barium. The barium and alumina in the filtrate were estimated. Residue from the water leaching was further subjected to washing with HCl till all acid soluble portion went into the filtrate which was analysed just as in the case of water extract. This solution in HCl was adopted with a view to the recovery of large amounts of barium and alumina which did not dissolve in water. From this solution $BaSO_4$ could be recovered by treating with H_2SO_4 formed from SO_2 produced in calcination while alumina could be crystallized out as sulphate or alum.

Analysis of barytes and bauxite used were as follows —

Barytes from Alwar State Rajputana	SiO_2	2·82 %
	Al_2O_3	0·28 %
	Fe_2O_3	0·11 %
	BaO	62·78 %
	CaO	0·94 %
	MgO	0·76 %
	SO_3	32·38 %
	Total	100·07 %
Bauxite from Katni	SiO_2	1·85 %
	Al_2O_3	58·83 %
	Fe_2O_3	3·50 %
	TiO_2	6·11 %
	CaO MgO	0·08 %
Loss on ignition	...	28·80 %
	Total	99·17 %

In analyses recorded in Tables I and II only barium was estimated because it was considered that the mixtures which gave good yields of barium provided large production of soluble aluminates and were best suited for subsequent trials

Table I

Temperature 1150°C Time of heating 4 hours

No	Ratio of barytes to bauxite	Approximate molecular formula	Percentage loss on heating	Percentage BaO extracted in water
1	100 40	$2BaO\ Al_2O_3$	19 5 %	V S*
2	100 50		28 5 %	16 0
3	100 60	$BaO\ Al_2O_3$	31 2 %	41 0
4	100 70		26 4 %	V S
5	100 80		25 0 %	V S
6	100 90	$2BaO\ 3Al_2O_3$	30 2 %	V S
7	100 100		27 9 %	22 0
8	100 111	$3BaO\ 5Al_2O_3$	28 9 %	41 2
9	100 125		29 4 %	35 4
10	100 143	$BaO\ 2Al_2O_3$	29 4 %	36 2
11	100 167		27 3 %	31 4

Compositions 3, 8, 9 and 10 are the best These are in fair agreement with the results of Booth and Ward The low yields of barium indicate that a temperature of about 1150°C was rather low

Table II

Temperature 1250 C—1300 C Time 4 hours

No	Ratio of barytes to bauxite	Approximate molecular formula	Percentage loss on heating	Percentage BaO extracted in water
1	100 100	$2BaO\ 3Al_2O_3$	28 19	28 0
2	100 60	$BaO\ Al_2O_3$	32 8	36 2
3	100 50	$BaO\ Al_2O_3$	34 4	41 2
4	100 60 With 2 5 % carbon	$BaO\ Al_2O_3$	29 4	43 2

*V S.—Very Small

In Table II it will be seen that a rise in temperature has generally increased the formation of soluble aluminate Further, the best composition was No 4 In this case, as expected, carbon has had some beneficial effect, though not much, by probably reducing the $BaSO_4$ into BaS which goes into reaction more readily However this much carbon is considered uneconomic and in future experiments it was decided to use only 1 %

Residue from water extraction in No 3 was treated with dilute HCl and in the acid solution BaO extracted was 34.4 % of the total Thus altogether BaO extracted became 75.8 %

In analyses recorded in Table III it was decided to see what results were obtained by using pure salts of barium and aluminium such that they were likely to easily enter into reaction to give barium aluminates, while to get comparative results mixtures of barytes-bauxite (Table IV) were heated side by side under the same conditions

Table III

Temperature 1300°C—1350 C Time 4 hours

Salts used—barium carbonate and aluminium acetate

No	Ratio of barium carbonate to aluminium acetate	Approximate molecular formula	Extraction in water % BaO	% Al_2O_3	% total extraction	Ratio Al_2O_3/BaO
1	591 510	$3BaO\ 5Al_2O_3$	55.4	50.1	57.5	0.846
2	197 240	$BaO\ Al_2O_3$	42.9	41.8	42.6	0.652
3	197 120	$2BaO\ Al_2O_3$	33.0	58.8	39.6	0.590
4	197 80	$3BaO\ Al_2O_3$	31.0	41.4	32.9	0.298
			Extraction in HCl			
1			10.8	28.4	18.3	4.48
2			5.7	33.8	17.4	3.94
3			3.0	19.6	7.1	2.19
4			4.0	6.8	12.9	1.71

The results of Table III provide interesting data In Nos 2 and 3 the ratio of Al_2O_3 to BaO is about 0·66 which corresponds to the molecular composition BaO Al_2O_3 Thus even when a mixture corresponding to the formula 2BaO Al_2O_3 is used, there seems to be a preponderance of BaO Al_2O_3 formed But in No 4 the ratio of Al_2O_3 to BaO should be 0·22 and the value obtained, 0·298, leads to the suggestion that probably along with others a compound 3BaO Al_2O_3 is formed The theoretical value for No 1 is 1·11 while the ratio obtained is 0·846. The variation is large and probably some compound BaO XAl_2O_3, where X is more than 1, is formed Very much higher values of this ratio in the case of acid extractions lead to a similar interpretation Thus it can be concluded that the compound which is largely formed and is most soluble in water is BaO Al_2O_3 The other compounds are formed in lesser amounts and are insoluble in water These conclusions are also supported by subsequent results

Table IV

Temperature 1300°C—1350°C Time 4 hours

Using barytes and bauxite with 1% carbon

No	Ratio of barytes to bauxite	Approximate molecular formula	Loss in weight on heating %	Extraction in water			
				% BaO	% Al_2O_3	Total extraction	Ratio Al_2O_3/BaO
1	100 : 142	BaO $2Al_2O_3$	31·0	5·4	9·9	6·3	1·980
2	100 : 121	3BaO $5Al_2O_3$	29·9	15·7	13·5	11·8	0·768
3	100 : 73	BaO Al_2O_3	31·2	41·9	41·3	36·8	0·666
4	100 : 60	BaO Al_2O_3	31·0	51·0	52·5	45·7	0·581
				Extraction in Hcl			
1				16·6	55·5	25·9	3·120
2				64·2	89·0	61·2	1·247
3				43·3	69·5	48·5	1·051
4				47·2	75·2	50·8	0·898

In order to determine how the impurities, iron of barytes and bauxite as well as the titania of the latter distributed themselves, the water solution and acid solutions of the barium aluminates were examined In every case these impurities were absent from the water extraction which contained nothing but Ba and Al However the acid extraction contained almost all iron and titania. This also explained the fact that the total percentage of alumina extracted in water and acid as given in Nos 2, 3 and 4 of Table IV exceeds 100 This is because the alumina as reported in the acid extract also contains Fe_2O_3 and TiO_2 which have not been separately estimated

Table V gives the results of two final experiments made with the best mixture (100 barytes 60 bauxite) under the best conditions. The heating was done in an oil-fired muffle for 2 hours at a temperature of 1400°C The sintered mass was as usual ground and first extracted with water and then with acid

Table V

No 1	Water Extract	HCl Extract
BaO	62 56 %	21 21 %
Al_2O_3	78 40 %	32 84 %
Total extraction	65 26 %	25 45 %
Ratio Al_2O_3/ BaO	0 68	0 76
Total extraction in water and acid		
BaO	83 77 %	
$Al_2O_3(+Fe_2O_3+TiO_2)$	97 06 %	

No 2	Water Extract	HCl Extract
BaO	57 86 %	34 43 %
Al_2O_3	73 70 %	58 10 %
Ratio Al_2O_3/BaO	0 68	0 89
Total extraction in water and acid		
BaO	92 29 %	
$Al_2O_3(+Fe_2O_3+TiO_2)$	—104 6 %	

In some further experiments iron and titania were estimated, quantitatively and it was found that in trials in which reaction was complete all the residue left after leaching with water was, with the exception of some silica, completely soluble in acid and this acid solution contained all the iron and titania

Thus in conclusion it may be said that a ratio of 100 parts barytes to 60 parts bauxite, heated for about 2 hours at a temperature of 1350°C—1400°C gave the best results. About 65% BaO from the $BaSO_4$ could be recovered in water soluble portion while the water insoluble residue was completely soluble in dilute HCl and allowed of the recovery of BaO and Al_2O_3

Gases evolved on heating —In the results tabulated above the loss in weight on heating indicated the extent to which reaction had taken place This loss was due to (a) water in the bauxite, (b) organic matter in the bauxite and lastly (c) the evolution of SO_2 and O_2 when alumina reacted with $BaSO_4$ The loss due to causes (a) and (b) took place in every case but that due to (c) was variable, depending upon the barium aluminate formed With the barytes-bauxite mixture 100 60 this loss theoretically was 32 5 % and in general the more the actual loss approximated to this figure, the better were the results obtained Numerous difficulties were experienced in trying to analyse these gases because the containers in which the mixtures were heated could not stand a temperature of 1450°C without cracking In the end a slipcast sillimanite retort which had been fixed to 1400°C was used In the neck of the retort a steel tube was screwed in To make the joint air-tight a paste of a fire-clay sillimanite mixture was used and then over this paste, when dry, a soft enamel was applied and vitrified over a flame The free end of the steel tube was connected to a series of bubblers containing different absorbants for CO_2, O_2, SO_2, etc The last bubbler was connected with a suction pump so that the velocity, of the gases could be controlled The retort was heated in a gas-fired furnace, the neck and joint being well out of the flames remained fairly cool A temperature of 1400°C could be easily attained in about 1½ hours

On heating, air and water vapour were first expelled and followed by CO_2 which continued up to about 900°C At this stage some H_2S was also detected The evolution then stopped but recommenced at about 1150 C—1200°C and continued for about an hour till 1400°C which was the highest temperature reached Final stoppage, though the temperature was maintained for another 30 minutes, showed that the reaction was complete in less than an hour SO_2 could be easily detected by its action on $KMnO_4$, Iodine and $K_2Cr_2O_7$ solutions and it was also passed through KOH, the sulphite formed being oxidised by H_2O_2 and estimated gravimetrically as sulphate The results obtained however were not quantitative KOH solution through which SO_2 had passed showed no test for sulphate before oxidation proving the absence of SO_3 being evolved as such The loss in weight of the powder was 32 % and the residue obtained after digesting it repeatedly with water, was completely soluble in acid Thus no $BaSO_4$ was left unchanged

Hydrolysis of barium aluminate —The barium aluminate formed in the reaction is a very unstable compound, having strong tendency to hydrolyse, precipitating $Al(OH)_3$ If water solutions were allowed to stand for 4 or 5 days all the alumina settled down leaving $Ba(OH)_2$ which gradually absorbed CO_2 from the atmosphere and changed to insoluble $BaCO_3$ It was thus impossible to keep a solution of $BaO\ Al_2O_3$ in water Various experiments showed that the rate of separation of $Al(OH)_3$ was considerably accelerated by the addition of some good electrolyte to the solution As in the case of the well-known Bayer's process in which $Al(OH)_3$ is precipitated from a solution of sodium aluminate, the best results were obtained by adding to the solution some freshly precipitated $Al(OH)_3$, which acted as a nucleus for further settling out, along with a little NH_4Cl In this way, a thick voluminous precipitate is thrown down and within a few minutes all $Al\ (OH)_3$ is separated leaving no Al in solution The concentration of the $BaO\ Al_2O_3$ solution was found to have no noticeable effect upon the rate of $Al\ (OH)_3$ precipitation

After the removal of Al $(OH)_3$ interest centred on the strength of $Ba(OH)_2$ solution left and the strength of NaOH that would result after causticization of the Na_2SO_4 Several determinations showed that a strength of 2 % $Ba(OH)_2$ solution was normally obtained When a 30% (nearly saturated at room temperature) solution of Na_2SO_4 was causticized with this $Ba(OH)_2$ solution, a strength of about 1% NaOH was formed With greater care in leaching a slightly higher strength of Ba $(OH)_2$ solution and subsequently of NaOH solution could be obtained

By treatment of the residue from water extraction, with H_2SO_4 it may be possible first to separate Fe, Al and Ti together as soluble sulphates from the insoluble $BaSO_4$ and then to isolate out the valuable Ti while Al could be converted to alum

From the hydrolysis of BaO Al_2O_3, the Al $(OH)_3$ can be separated and either calcined to give pure Al_2O_3 which is in good demand or treated variously to give $AlCl_3$, Al_2 $(SO_4)_3$ and alum which are articles of commerce

The above experiments clearly establish that the reactions given in steps 1 and 2 of the process (pages 40-41) take place quite satisfactorily and trials on a semi-commercial scale would definitely prove the industrial possibilities of the process.

The raw materials required are abundantly found in this country and the United Provinces is favourably situated in so far as all four of them, *viz*, bauxite, salt, barytes and coal can be easily obtained at a place like Agra Bauxite occurs plentifully in India at many places and has so far found little use in the country Prominent deposits are in Bombay, Kashmir, C P and Bihar, but for this province the deposits best situated to give good quality material are at Katni in C P There is almost no market for barytes either which is mainly found in Madras Presidency and in Alwar State The Alwar deposits, being quite close to Agra, are particularly suitable for U P There are four centres of salt production which runs into millions of tons in this country, *viz*., Bombay coast, Madras coast, Salt Range in the Punjab and Sambhar Lake in Rajputana In the last locality, *viz*, Sambhar Lake the salt produced is of a good quality and being nearest to U P holds out the greatest promise Coal will undoubtedly have to be obtained from Bihar

A detailed consideration of the economics of the process shows that in India it has decided advantages over the electrolytic process of NaOH manufacture, and the writers, after making all estimates, are convinced that the price of the by-products alone is sufficient to meet almost the entire cost of production and even if all the alumina produced cannot be consumed in the market, the process can compare favourably with any other and leaves a good margin of profit after meeting all costs

Reference

1 Booth and Ward (1933), *Jour Phys Chem*, 36, 961

CHEMICAL EXAMINATION OF *INDIGOFERA LINIFOLIA* RETZ. THE ISOLATION OF ITS ACTIVE PRINCIPLE

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SUMMARY

From the alcoholic extract of the plant (I) an unsaturated lactone $C_2\ H_{40}O_2$ (linifolin), m.p 95° 96°C, and (II) a wax $C_{42}H_{84}O_2$, m p 78° 79°C which is a ceryl ester of palmitic acid, have been isolated in addition to tannins, phylobaphenes and glucose

Indigofera linifolia, Retz is a common annual herb belonging to the Natural Order—Leguminoceae, the stem being slender and copiously branched, the leaves simple and typically linear and the fruit a pod It is distributed from the Himalayas throughout India and is called Torki in Hindustani and Bhangra in Bengali It is given by medical practitioners in febrile eruptions According to Revd A Campbell the plant is used by Santals in amenorrhoea along with *Euphorbia thymifolia*

As nothing is known regarding the chemical composition of *Indigofera linifolia*, though Chatterji and Dutt[1] while working on another variety of *Indigofera*, viz , *I enneaphylla*, isolated two unsaturated hydrocarbons of very high molecular weights and having the molecular formulas $C_{70}\ H_{140}$ and $C_{90}\ H_{151}$ respectively, so the present authors were tempted to put the plant to a systematic chemical analysis and to find whether the occurrence of hydrocarbons in the plants belonging to the N O Leguminoceæ is of wider occurrence or not But so far we have not been able to isolate any hydrocarbon from the plant and we could isolate a wax and a substance of the nature of an unsaturated laclone which is named as 'Linifolin'

Linifolin has a molecular formula $C_{28}H_{50}O_2$ and contains no alcoholic or phenolic hydroxy group as it does not form any acetyl or benzoyl derivative and gives no colour with alcoholic ferric chloride It dissolves in alcoholic caustic alkalis with a yellow colour Although containing no aldehydic or ketonic group it reduces Tollen's reagent slowly and gives no colour with an alkaline solution of potassium nitroprusside. It readily reduces an alkaline solution of potassium permanganate and also a solution of bromine in chloroform These reactions definitely prove it to be a member of the $\Delta\alpha\beta$ unsaturated lactones which have been adequately reviewed by Jacobs.[2] The two oxygen atoms present in the molecule are accounted for in the lactonic ring of the molecule and more work on the elucidation of its constitution is in progress

EXPERIMENTAL

30 Kg of the entire plant were collected locally and dried in the sun The fresh plant lost 42 51 % of moisture during the process of drying 10·2 gm were then finely crushed and on complete incineration it yielded 21 74 % of a grey coloured ash, 29 56 % of which was water soluble The following radicals were detected —

(a) In the water soluble portion —SO_4, Cl, Ca, Na and K
(b) In the water insoluble portion —Al, Fe, Mg, Si, CO_3

In order to have an idea about the solubility of the constituents of the plant, fifteen grams of the dried and powdered stuff were exhaustively extracted with the following solvents in succession with the results given below —

Benzene extract —The extract was of a deep green colour, containing a greenish white crystalline matter suspended in it, yield 12 32 %

Alcoholic extract —The extract was a brown pasty mass, gave dark brown colour with ferric chloride and reduced Fehling's solution and formed normal as well as basic lead salts, and gave no test for alkaloids, yield 18 76 %

Chloroform extract —The extract was of a light green colour with some needle-shaped crystalline matter suspended in it, yield 7 29 % Acetone extract (2 04 %) and ethyl acetate extract (1 49 %) were of brown colour and reduced Fehling's solution

The powdered material (1 5 Kg) was extracted with boiling alcohol in a big extraction flask of 5 litre capacity for five times The extract which was of deep green colour was filtered hot and on leaving overnight it deposited some crystalline material which was filtered and washed with cold alcohol repeatedly till a perfectly white stuff was obtained, which was then dried A large number of extractions with the fresh plant were done in a similar way On concentrating alcoholic mother liquor after separating the solid precipitate and also the washing, to about one-fourth of its original volume, some more of the insoluble precipitate was obtained and it was found to be the same substance which separated from the hot alcoholic extract on cooling

The insoluble precipitate after drying was extracted first with cold petroleum ether till whole of the chlorophyll was removed and then with hot petrol ether (A) The petroleum ether insoluble portion was then extracted with hot benzene and after filtration it was concentrated whereby some dirty white crystalline substance separated It was crystallised first from a mixture of methylalcohol and benzene whereby some brown waxy matter was left and then for a number of times from benzene whereby it separated in the form of a white crystalline powder which under the high power of the microscope appeared as thick rods melting at 95°-96°C.

Properties of linifolin.—Linifolin is a colourless substance, insoluble in water, soluble in benzene, phenol, chloroform, ether and slightly so in ethyl and methyl alcohols, ethyl acetate and acetic acid. It dissolves in alcoholic caustic potash or soda solution on warming, giving a yellow coloration. It decolorises a solution of bromine in chloroform and a dilute alkaline solution of potassium permanganate. It dissolves in concentrated sulphuric acid on warming with a deep red colour. It gives no precipitate with lead acetate or silver nitrate and no colour with ferric chloride. Tollen's reagent is reduced slowly by it and forms no acetyl or benzoyl derivative and neither an oxime is formed, and it gives no colour with an alkaline solution of potassium nitroprusside. (yield 0.1 %.)

(Found: C, 78.97, 78.87; H, 13.00, 12.95; M.W. (ebullioscopic in benzene) 410, 428; $C_{26}H_{50}O_2$ requires C, 79.18; H, 13.14 %; M.W. 394.)

Action of alcoholic potash on linifolin.—Linifolin (1.5 gm.) was saponified by boiling with 0.1N-alcoholic potash. When the saponification was complete, the yellow solution was cooled, the alcohol removed by distillation and the mass acidified with dilute hydrochloric acid when a voluminous flocculent precipitate separated which was collected and crystallised from benzene as a white crystalline powder, m.p. 96°. When a mixed melting point of this with the authentic sample of linifolin was taken, no depression occurred.

(Found: C, 78.72; H, 13.86; $C_{26}H_{50}O_2$ requires C, 79.18; H, 13 %.)

Neutralisation value of linifolin.—Titration of linifolin with standard alkali was possible partially and the neutralisation value was found to be 39.59 while $C_{26}H_{50}O_2$ requires (N.V.) 142.13.

The hot petroleum ether extract (A) of the insoluble solid precipitate was concentrated to a small volume and ethyl alcohol added until the whole of the dissolved substance was precipitated. It was then filtered and dried and crystallised for a number of times from petroleum ether until it was perfectly white and the melting point became constant. It separates in the form of a white crystalline powder which under the high power of the microscope appears as soft small rods and under polarised light appears as a soft white mass, melting at 78°-79°C.

It is soluble in hot petroleum ether, benzene, chloroform acetone and also in ethyl and methyl alcohols and is insoluble in water. It does not dissolve in cold concentrated sulphuric acid but on heating it dissolves with decomposition. It is unreacted by fuming nitric acid either in cold or hot. It gives no colour with ferric chloride, does not reduce Fehling's solution and gives no test for sterols. It does not form an acetyl or benzoyl derivative or an oxime. It gets saponified by alcoholic caustic potash solution and, on acidification, a white substance is precipitated, which melts indefinitely between 58°—72°C On crystallising twice from aqueous alcohol the substance melts at 61°C and is identified as palmitic acid From the above reactions it is clear that the substance is of the nature of a wax, (yield 02%) (Found C, 81 27, 81 09, H, 13 58, 13 86, $C_{42}H_{84}O_2$ requires C, 81·29, H, 13 55 per cent.) The wax had the acid value 11 87 and the saponification value 49 78, and the wax is a ceryl ester of palmitic acid which has got the same melting point (79°C) as well as the same molecular formula ($C_{42}H_{84}O_2$)

The mother liquor from the alcoholic extract after separating the solid precipitate was diluted with alcohol and a dilute solution of lead acetate added The insoluble lead salt was filtered and decomposed with a current of sulphuretted hydrogen in alcoholic suspension and the mother liquor concentrated But from this nothing crystalline could be obtained and it was of dark brown colour and showed the presence of tannins in large amount and melted indefinitely between 157°—218°C

The filtrate from the lead salt was decomposed with hydrogen sulphide, the mother liquor diluted with water, a hot solution of basic lead acetate added The basic lead salt on decomposition and concentration gave nothing crystalline but showed the presence of phlobaphenes and the filtrate from the basic lead salt reduced Fehling's solution readily, and gave a glucosazone m p 203°C, showing thereby the presence of glucose among the reducing sugars

One of us (M P G) wishes to express his indebtedness to the Kanta Prasad Research Trust of the Allahabad University for a scholarship which enabled him to take part in this investigation

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STUDIES ON THE TREMATODE PARASITES OF FISHES

A NEW TREMATODE *NIZAMIA HYDERABADI*, N. GEN., N. SP., FROM THE INTESTINE OF A FRESH-WATER FISH, *OPHIOCEPHALUS PUNCTATUS*

By J. Dayal

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Received April 14, 1938

SUMMARY

Nizamia hyderabadi is a small trematode 1·05 mm long by 0·37 mm broad. The cuticle is smooth. Oral sucker is larger than ventral sucker. Prepharynx and pharynx are well developed, oesophagus is small. Excretory bladder is Y shaped. Genital opening is immediately in front of the ventral sucker a little to the right. Testes are deeply lobed and ovary is trilobed. Cirrus sac is large and contains an oval vesicula seminalis interna, tubular pars prostatica and a retracted cirrus. Vesicula seminalis externa is divided into two spherical portions. Vitelline glands extend from the ovary to the posterior end, lateral only in front of the anterior testis and extending towards the middle line posteriorly. Laurer's canal is present and the uterus at its origin is full of sperms. A receptaculum seminis is absent. Eggs are operculated.

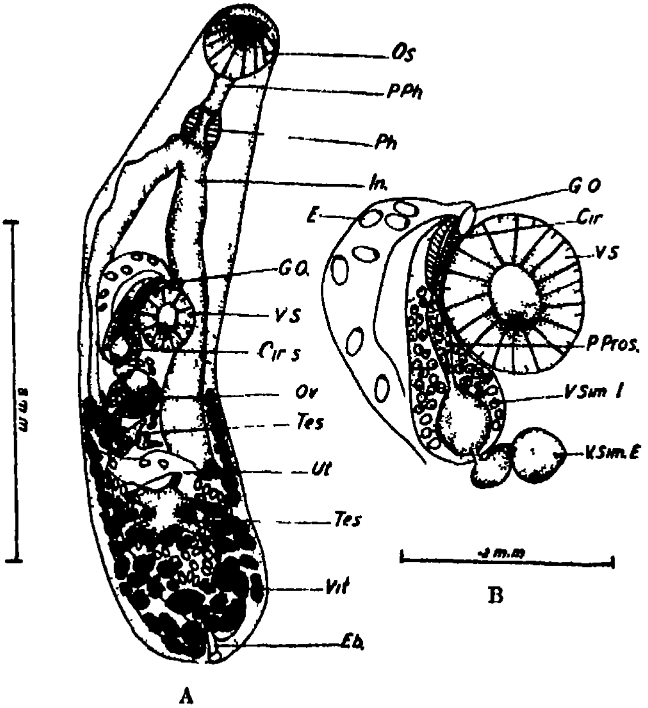
The relationship of ***Nizamia*** is discussed and a new subfamily Leptophallinae is erected to include it and the related genera, ***Leptophallus***, ***Ganada*** and ***Neoganada***. A key to the genera of the new subfamily is given in the paper.

Lühe[5] (1909) described *Leptophallus nigrovenosus* from the oesophagus of *Tropidonotus natrix*. Chatterji[2] (1933) and Dayal[3] (1938) described *Ganada clariae* and *Neoganada barabankiae* respectively, from the intestine of *Clarias batrachus*. The form described in the present communication is related to *Leptophallus*, *Ganada* and *Neoganada*, but differs from them in several important characters which necessitate the erection of a new genus for its reception.

The trematodes were collected at Hyderabad, Deccan, in January 1937 from the intestine of *Ophiocephalus punctatus*.

Nizamia hyderabadi, N Gen, N Sp

Nizamia hyderabadi is a small cylindrical trematode with rounded anterior and posterior ends It is 1 65 mm long by 0 37 mm wide The cuticle is smooth being devoid of spines



A—Ventral view of *Nizamia hyderabadi* B—Cirrus sac of *Nizamia hyderabadi*

Cir Cirrus, ***Cir S*** Cirrus sac, ***E*** Eggs, ***Eb*** Excretory bladder, ***G O*** Genital opening, ***In*** Intestinal caeca, ***Os*** Oral sucker, ***Ov*** Ovary, ***Ph*** Pharynx, ***P Ph*** Prepharynx, ***P Pros*** Pars prostatica, ***Tes*** Testis ***Ut*** Uterus, ***Vit*** Vitelline glands, ***V S*** Ventral sucker ***V Sim I*** Vesicula seminalis interna, ***V Sim E*** Vesicula seminalis externa.

The oral sucker is oval and subterminal It is 0 16 mm long by 0 17 mm broad. The acetabulum is smaller than the oral sucker and is 0 15 mm long by 0 13 mm broad It lies at a distance of 0 68 mm from the anterior end.

The mouth lies at the anterior end of the oral sucker and leads into a long prepharynx about 0 1 mm long by 0 04 mm broad The latter opens into a strong muscular pharynx 0 07 mm long by 0 08 mm broad Posterior to pharynx is a short œsophagus which divides into two simple intestinal caeca, which run up to the posterior end of the body

The excretory pore is situated at the posterior end of the body It leads into a long tubular bladder which branches into two short diverticula behind the posterior testis

The genital opening lies immediately in front of the ventral sucker, a little to the right of the median line

The male reproductive organs consist of two deeply lobed testes lying one behind the other The anterior testis is situated immediately behind the ovary at a distance of 1 mm from the anterior end It is 0 06 mm long by 0 12 mm broad The posterior testis is larger than the anterior one, and is situated at a distance of 1 14 mm from the anterior end, and 0 08 mm behind the anterior testis It is 0 17 mm long by 0 18 mm wide

The cirrus sac is a long flask-shaped organ lying on the right side of the acetabulum It is 0 24 mm long by 0 09 mm wide The organs contained within the cirrus sac are the vesicula seminalis interna, pars prostatica, a muscular cirrus and prostate gland cells The vesicula seminalis consists of two parts, a vesicula seminalis interna lying within the cirrus sac, and a vesicula seminalis externa lying outside the cirrus sac freely in the parenchyma The vesicula seminalis interna is oval in shape and is 0 06 mm long by 0 05 mm wide. The vesicula seminalis externa extends up to the ovary and is divided into two portions, an anterior portion which is oval and is 0 03 mm long by 0 05 mm wide, and a posterior spherical portion with a diameter of 0 05 mm The vesicula seminalis interna opens through a short duct into a long tubular pars prostatica 0 07 mm long by 0 02 mm wide The latter opens through a short ejaculatory duct into a retracted muscular cirrus 0 07 mm long by 0 02 mm wide, which opens to the exterior at the genital pore

The ovary is a trilobed organ with a maximum length of 0 11 mm and a maximum breadth of 0 14 mm It lies at a distance of 0 92 mm from the anterior end From its right posterior lobe arises the oviduct which opens at the ootype The Laurer's canal is present. The receptaculum seminis is absent but the uterus at its origin is full of sperms

The vitelline glands consist of large follicles extending from the ovary to the posterior end They are lateral in position anterior to posterior testis, while posteriorly they extend towards the middle line The two transverse vitelline ducts formed by the union of other ducts unite in the region of anterior testis and open into the öotype.

The uterus arises from the right side of the ootype opposite the opening of the oviduct, and runs in a sinuous manner between the two testes to a distance of about 0 15 mm in front of the posterior end, where it bends and runs forward through the same course to open at the genital pore The terminal portion of the uterus is not muscular and lies on the right side of the cirrus sac.

The eggs are oval, operculated and covered over by a thin brown shell They measure 0 030 mm by 0 016 mm

The distinguishing characters of the form described may be summarised as follows -

1 Cylindrical body devoid of spines
2 Large prepharynx, and muscular pharynx
3 Testes and ovary deeply lobed
4 Cirrus sac large, with oval vesicula seminalis interna, tubular pars prostatica and a retracted cirrus.
5 Vesicula seminalis externa divided into two portions
6 Vitelline glands with large follicles extending from the ovary to the posterior end, lateral only anterior to posterior testis, and extending towards the middle line posteriorly
7 Laurer's canal present and uterus acting as receptaculum seminis
8 Eggs operculated

Discussion —The new form *Nizamia hyderabadi*, as will appear from the description, is closely related to *Leptophallus*, *Ganada* and *Neoganada* It however differs from all of them in the possession of a long prepharynx, short œsophagus, in the structure of the cirrus sac, chiefly in having vesicula seminalis externa divided into two portions, in the possession of deeply lobed testes and trilobed ovary, and in having operculated eggs. Further it differs from *Leptophallus* and *Neoganada* in the absence of receptaculum seminis, and from *Ganada* in the structure of vesicula seminalis interna and externa, and in the shape of the pars prostatica These differences along with the topography of organs are enough to erect a new genus *Nizamia* with the following diagnosis —

Plagiorchidæ, body cylindrical, cuticle without spines Prepharynx long, pharynx strong and muscular, œsophagus very small Intestinal cæca simple reaching to the posterior end Genital opening in front of the ventral sucker a little to the right of the median line Testes deeply lobed one behind the other Cirrus sac large, on the right side of the ventral sucker Vesicula seminalis consists of two parts, vesicula seminalis interna lying within the cirrus sac, and vesicula seminalis externa lying outside the cirrus sac The vesicula seminalis externa is divided into two portions Tubular pars prostatica and a retracted cirrus present. Ovary trilobed Laurer's canal present, receptaculum seminis absent, uterus at its origin filled with sperms Vitellaria with large follicles extending from the ovary to the posterior end, lateral only in front of the posterior testis and extending towards the middle line posteriorly Uterus with descending and ascending limbs running between the testes Eggs oval and operculated.

The genera *Leptophallus*, *Ganada*, *Neoganada* and *Nizamia* differ from all other members of the family *Plagiorchidæ* in having vesicula seminalis divided into two portions, a vesicula seminalis interna lying within the cirrus sac, and a vesicula seminalis externa lying outside the cirrus sac, free in the parenchyma. Baer[1] (1924) and Mehra[6] (1931, 1937) included the genus *Leptophallus* Luhe in the subfamily *Brachycoeliinae* Looss (1899). The genera *Leptophallus* and *Brachycoelium* differ from each other chiefly in the extent of intestinal caeca, and in the structure of the cirrus sac. Mehra[6] (1937) has used these characters, chiefly the structure of the cirrus sac and the vesicula seminalis, as subfamily characters, in the classification of the family *Plagiorchiidae*. Therefore on the basis of the classification as given by Mehra[6] (1937), and supported by Olsen[7] (1937) the genera *Leptophallus*, *Ganada*, *Neoganada* and *Nizamia* should be placed in a new subfamily *Leptophallinae* with the following diagnosis —

Plagiorchiidae, cuticle smooth or covered with spines. Prepharynx, pharynx and oesophagus present. Length of intestinal caeca variable usually reaching to posterior end of the body. Excretory bladder Y-shaped, with long stem and short diverticula. Genital pore in front of acetabulum. Testes connubial or tandem. Cirrus pouch generally crescentic. Vesicula seminalis divided into vesicula seminalis interna and externa lying within and outside the cirrus sac respectively. Ovary in front of testes. Laurer's canal present. Receptaculum seminis present or absent. Vitelline glands with large follicles, usually lateral. Uterus with transverse coils extending to posterior end of the body. Eggs numerous with or without operculum.

Key to the genera of the subfamily Leptophallinae, N. Sub. Fam.

1 Receptaculum seminis present ... 2
Receptaculum seminis absent ... 3

2 Intestinal caeca short not extending to posterior end, testes symmetrical, cirrus pouch anterior to acetabulum, vitelline glands from pharynx to acetabulum ... *Leptophallus*

Intestinal caeca extending to posterior end, testes one behind the other, cirrus sac large, crescentic, lateral to acetabulum, vitelline glands lateral, extending to posterior end, uterus with transverse coils ... *Neoganada*

3 Testes spherical lying one behind the other, vesicula seminalis interna tubular, vesicula seminalis externa a simple sac like organ ... *Ganada*

Testes deeply lobed lying one behind the other, vesicula seminalis interna oval, vesicula seminalis externa divided into two portions, ovary lobed, Laurer's canal present, uterus acting as receptaculum seminis, eggs operculated ... *Nizamia*

I am deeply indebted to Dr G S Thapar for his kind help and placing at my disposal his valuable library. My thanks are also due to Dr B K Das of the Osmania University for permitting me to collect the trematodes in his laboratory.

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CHEMICAL EXAMINATION OF THE FRUITS OF *PHYSALIS PERUVIANA* OR CAPE GOOSEBERRY, PART III

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Communicated by Dr S. Dutt

Received January 10, 1938

SUMMARY

From the husk of the berries of *Physalis peruviana* have been isolated potassium chloride admixed with potassium citrate (0·15%), a phytosterol C_{27} H_{44} O, H_2O m p 132°C (uncorr) (yield 0·04%), oleic, linolic, linolenic and saturated acids, a trace of a pungent alkaloid, an amorphous bitter glucoside C_{45} H_{64} O_{18} m p 100° 102°C (uncorr) (yield 0·3%) besides considerable amount of tannins, phlobaphenes and reducing sugars.

Physalis peruviana (N O Solanaceæ) called Cape-gooseberry in English and Makoi in Hindustani is cultivated in India, as it affords an excellent fruit. As far as the author is aware the fruits have not been chemically examined and consequently the husk which has been accidentally found to be very bitter in taste was subjected to detailed chemical examination

Several members of the extensive genus *Solanaceæ* have been reported to contain gluco alkaloids, for example solanine-t and solanine-s isolated from *Solanum tuberosum* and *Solanum sodomoeum* are well known as the result of the recent work [2, 3, 5, 6, 8, 10, 11] by Oddo and his co-workers as well as others. Solangustine C_{33} H_{53} O_7 N which on hydrolysis gives glucose and solangustidine C_{27} H_{43} O_2 N has been isolated from *Solanum augustifolia* and solanocapsine C_{25} H_{42} O_2 N_2 or C_{26} H_{44} O_2 N_2 and solanocapsidine, probably C_{26} H_{42} O_4 N_2 have been isolated from *Solanum pseudocapsicum*, (winter cherry) [1]

Saiyed and Kanga[7] have isolated from the whole plant *Solanum xanthocarpum* carpesterol $C_{36}H_{54}O$, an alkaloid solancarpidine, $C_{26}H_{43}O_{3}$ and a glucoalkaloid solanacarpine $C_{44}H_{77}O_{19}N$ Gupta and Dutt[4] as a result of detailed investigation of the seeds of this plant have isolated the glucoalkaloid, solanacarpine $C_{44}H_{74}O_{11}N_{2}$ giving on hydrolysis glucose, rhamnose and solanacarpidine to which the formula $C_{32}H_{54}O_{2}N_{2}$ has been assigned. Besides the glucoalkaloid they have recorded the isolation of carpesterol, $C_{36}H_{57}O_{4}$ m.p 248 C and a lactone $C_{28}H_{42}O_{7}$ m p 78 C

The present investigation was undertaken in the hope of isolating the bitter principle as well as glucoalkaloid if any from the husk of *Physalis peruviana*. The husk has been found to contain 0 15% of potassium chloride admixed with potassium citrate, 0 04% of a phytosterol $C_{27}H_{44}O, H_{2}O$ m p 132°C besides oleic, lenolic, linolinic (traces) and saturated acids The husk also contains an uncrystallisable pungent alkaloid in traces, and an amorphous bitter principle having the formula $C_{45}H_{66}O_{18}$ m p 100°-102°C besides considerable amount of tannins, phlobaphenes and reducing sugars

EXPERIMENTAL

In order to form an idea about the solubility of the constituents of the husk 30 gms of the powdered stuff were extracted in a Soxhlet's apparatus with various organic solvents in succession when the following amounts of extracts dried at 100° C were obtained

Petroleum Ether Extract —Pale yellow semi-solid waxy mass, yield 4·91%

Benzene Extract —Greenish brown mass containing fatty matter and carotinoids and bitter in taste. Yield 4 00%

Ethyl Acetate Extract —Brown mass, slightly bitter in taste and gave a green colour with ferric chloride, yield 2 45%

Alcoholic Extract —Brown resinous mass having an intense bitter taste Water partially dissolved it giving a brown solution which gave deep green coloration with ferric chloride (tannins and phlobaphenes) and a brown resinous mass remained undissolved Yield 8 4%

For complete examination 5 kgms of the coarsely powdered husk were in lots of 700 gms repeatedly extracted with rectified spirit in a 5 litre extraction flask until the extraction was complete The combined brownish yellow extracts were distilled until most of the solvent had been recovered and the residue boiled frothily. On allowing the concentrated extract to stand for a month it deposited a considerable amount of gritty crystalline stuff and some greenish brown resinous mass After addition of sufficient alcohol to completely dissolve the resinous mass it was filtered at the pump, and the residue well washed with alcohol After crystallisation from water it was obtained as shining white crystalline mass and was found to consist mainly of potassium chloride and traces of potassium citrate (7·5 gm.).

From the filtrate alcohol was removed as completely as possible under reduced pressure and the residue left was repeatedly extracted with benzene. The combined benzene extracts were concentrated after filtration and the green oily viscous mass thus obtained could not be crystallised and was finally saponified by boiling with a slight excess of 20% alcoholic caustic potash. The residue left after complete removal of alcohol was treated with water and repeatedly extracted with ether. The small amount of unsaponifiable matter obtained on repeated crystallisation from small quantities of alcohol was obtained as silky needles melting at 132°C and gave all the usual colour reactions of sterols. (Found C, 84·0%, H, 10·0%, $C_{27}H_{44}O, H_2O$ requires C, 84·3%, H 10·4%.)

The soap after the removal of the unsaponifiable matter was treated with 500 cc. of water when a considerable portion of brownish grey stuff remained undissolved. It was acidified with dilute sulphuric acid and heated on the water bath. The free fatty acids were removed by extraction with petroleum ether (0·4% by weight of the husk) and were separated into saturated (11·6%) and unsaturated acids (88·4%) by Twitchell's lead salt alcohol method. The unsaturated acids having iodine value 128·8 were found by bromine method to consist mainly of oleic and linoleic acids and a trace of linolenic acid.

The concentrated alcoholic extract (A) after removal of chlorophyll and waxy matter was dissolved in alcohol and on keeping for several days did not deposit any crystalline stuff. It was found to give copious precipitates with alkaloidal reagents but as the solution turned milky on the addition of water and deposited sticky brown mass, the tests with alkaloidal reagents were not reliable and did not go to show conclusively the presence of alkaloidal bodies. A measured amount of the alcoholic solution was taken and after complete removal of alcohol was repeatedly extracted with cold dilute hydrochloric acid. The acidic solution after neutralisation with ammonia and repeated extraction with chloroform and removal of the latter by distillation gave a trace of a brown viscous stuff having a strong ammoniacal smell, and having a pungent but not bitter taste. Its solution in dilute hydrochloric acid gave positive tests with alkaloidal reagents. All this went to indicate that the bitterness of the husk of *Physalis peruviana* is not due to an alkoloidal body.

As the reddish brown alcoholic solution (A) gave with alcoholic lead acetate first a dirty brown precipitate and then a bright yellow precipitate it was considered advisable to try the lead salt method. The alcoholic solution was treated in the cold with a small quantity of alcoholic lead acetate solution drop by drop till the formation of dirty brown precipitate had ceased and bright yellow precipitate began to separate. The resulting precipitate was filtered at the pump and well washed with alcohol and hot water and on decomposition with sulphuretted hydrogen in alcoholic suspension and concentration of the filtrate after removal of lead sulphide gave only tannins and phlobaphenes. The filtrate from the brown lead lake was treated in the hot with a slight excess of alcoholic lead acetate and the resulting bright yellow lead lake on decomposition with sulphuretted hydrogen in alcoholic suspension gave a brownish solution which on concentration deposited no crystalline stuff and consisted of tannins, phlobaphenes and was not bitter but astringent in taste.

The filtrate after complete precipitation with lead acetate gave a bulky and sticky yellow precipitate on dilution with water Consequently precipitation with basic lead acetate was considered to be useless and the alcoholic filtrate was treated with excess of hydrogen sulphide and the resulting lead sulphide filtered off, and repeatedly extracted with boiling alcohol and the filtrate combined with the main The filtrate after concentration and dilution with water gave a viscous precipitate which was repeatedly washed with water and crumbled to a fine brownish powder Attempts to crystallize it from various solvents failed. It has an extremely bitter taste and contained C, H and O, only It is sparingly soluble in hot or cold water, benzene, petroleum ether, ether, chloroform and carbon tetrachloride and readily in methyl and ethyl alcohol and in acetone In alcoholic solution it gives a green coloration with ferric chloride dissolves to a yellow solution in alkali hydroxides but not in alkali carbonate solutions With concentrated H_2SO_4 in presence of a little acetic anhydride a pinkish violet coloration (Liebermann's cholesterol reaction) It reduces Tollen's reagent on continued boiling but Fehling's solution only after hydrolysis with dilute mineral acids, and melts at 100°—102°C (Found C, 60 24, 60 37, H, 7 71, 7 84, M W in ethyl alcohol ebullioscopically 918, $C_{45}H_{66}O_{18}$ requires C, 60 4, H, 7 4%, M W 894)

The author wishes to convey his heartiest thanks to Dr S Dutt, D Sc, P R.S., for his kind interest in the investigation

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A NEW TREMATODE, *GORGOTREMA BARBIUS*, N. GEN., N. SP., FROM A FRESH-WATER FISH, *BARBUS SARANA*

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Received April 30, 1938

SUMMARY

Gorgotrema barbius is a dorsoventrally flattened trematode with a broad nearly circular posterior portion and a long neck like anterior portion of the body. The cuticle is covered with small scattered spines. A funnel shaped buccal cavity is present. Oesophagus is long and the intestinal caeca are simple and broad. Excretory bladder is tubular with lateral branches. Genital opening is in front of the intestinal bifurcation. A genital atrium is present. Testes are follicular (34–40 follicles). Uterine coils are posterior to ŏotype, mostly intercaecal. The relationship of the new form is discussed in the paper.

The trematodes were collected from the kidneys of a fresh-water fish, *Barbus sarana*. They belong to the family Gorgoderidae Looss (1901) and the subfamily Gorgoderinae Looss (1899). But they differ from all the known genera in important characters which necessitate the erection of a new genus for its reception.

Gorgotrema barbius, N. Gen., N. Sp.

The new form *Gorgotrema barbius* is a dorsoventrally flattened trematode of white colour. The cuticle is covered with small scattered spines. The anterior portion of the body is narrow and elongated, while the posterior portion of the body is much expanded and nearly circular. The worm is 4·4 mm long by 2·95 mm broad. The narrow anterior part is 1·87 mm long by 0·96 mm broad in the region of the genital opening, and the posterior expanded portion is 2·53 mm long by 2·95 mm broad.

The oral sucker is oval and subterminal. It is 0·47 mm long by 0·44 mm wide. The ventral sucker is larger than the oral sucker and oval in shape. It is 0·45 mm long by 0·47 mm wide. It is situated at the junction of the neck-like projection and the broad portion of the body, at a distance of 1·57 mm from the anterior end.

The mouth is a slit-like opening on the ventral side of the oral sucker and opens into a funnel-shaped buccal cavity. The latter leads into a long oesophagus 1·08 mm long by 0·05 mm broad. The oesophagus bifurcates into two simple and broad intestinal caeca which terminate at a distance of 0·6 mm from the posterior end of the body.

The excretory pore is situated on the ventral side near the posterior end of the body It leads into a long tubular bladder extending as far as the posterior follicles of the testes. A number of excretory tubules open on either side of the excretory bladder throughout its entire length

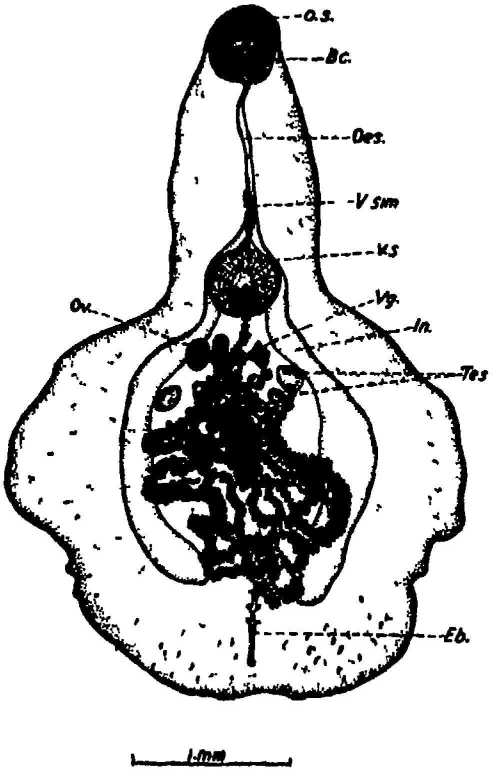

Fig 1

Ventral view of *Gorgotrema barbius*

Bc Buccal cavity, ***De*** Ductus ejaculatorius ***Eb*** Excretory bladder, ***In.*** Intestinal caeca, ***Met*** Metraterm, ***Od.*** Oviduct, ***Oes*** Oesophagus, ***Oot*** Öotype, ***Os*** Oral sucker, ***Ov*** Ovary, ***Pr*** Prostate glands, ***Sg*** Shell glands, ***Tes*** Testes, ***Ut*** Uterus, ***Vg*** Vitelline glands, ***V sim*** Vesicula seminalis, ***V S*** Ventral sucker

The genital opening is situated between the oral sucker and the intestinal bifurcation, at a distance of 1 18 mm from the anterior end and 0 3 mm in front of the intestinal bifurcation It leads into a common genital atrium into which open both the male and the female genital ducts

The male reproductive organs consist of a large number of small rounded or oval testes. They are scattered irregularly in the anterior half of the broad portion of the body, behind the ovary and between the intestinal caeca. The number of testes is between 34 and 40 In the type specimen the number is 38.

The cirrus sac is absent. The vesicula seminalis lies freely in the parenchyma and is oval in shape. It is 0·075 mm long by 0·06 mm wide and opens into a short ejaculatory duct 0·03 mm long The latter opens into the genital atrium on the left side of the opening of the female duct.

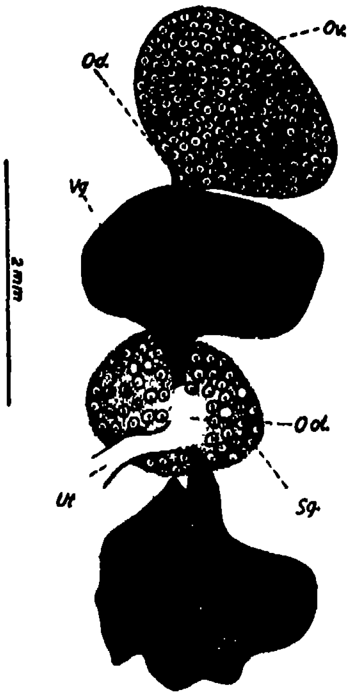

Fig 2
Ovary and ootype complex of *Gorgotrema barbius*
Lettering as in Fig 1

The female organs consist of an ovary and its duct together with a number of accessory organs associated with it. The ovary is situated on the right side of the right vitelline gland, and is partly internal to and partly overlaps the right intestinal caecum on the ventral side It is oval in shape and lies at a distance of 2·15 mm. from the anterior end It is 0·19 mm long by 0·14 mm broad From its left side arises the oviduct which opens into the ōotype The vitelline glands consist of two large, undivided follicles. They are situated in the middle of the body, on either side of the ōotype, behind the ventral sucker The right vitelline gland is 0·2 mm. long by 0·12 mm broad, and is situated at a distance of 2·1 mm from the anterior end. The left vitelline gland is irregular in outline and is 0·18 mm long by 0·17 mm broad. It is situated at a distance of 2·16 mm. from the anterior end. The ducts from the two glands open separately at the ōotype. A large number of unicellular shell-glands, each with a large nucleus, surround the ōotype

The uterus arises from the posterior side of the ŏotype between the openings of the vitelline ducts It runs backwards forming coils mainly between the intestinal caeca, but also extends over the latter on the ventral side Anteriorly it runs dorsal to the ventral sucker to open at the genital atrium on the right side of the opening of the male duct.

The eggs are oval in shape with a thin light-brown shell They measure 0 031-0 035 mm. by 0 022-0 024 mm

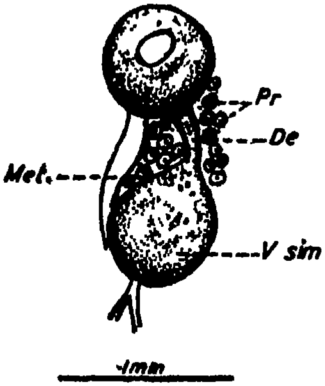

Fig. 3

Vesicula seminalis and metraterm of *Gorgotrema barbius*
Lettering as in Fig 1

The distinguishing characters of the new form may be summarised as follows —

1 Body flat, divided into an anterior elongated neck-like portion and a posterior broad circular portion
2 Cuticle covered with small scattered spines.
3 A funnel-shaped buccal cavity present. Oesophagus long, intestinal caeca simple and broad.
4 Excretory bladder tubular with lateral branches
5 Genital opening anterior to intestinal bifurcation
6 A common genital atrium both for male and female ducts present
7 Testes follicular, in large numbers (34—40), scattered in the anterior half of the broad portion of the body.
8 Uterine coils posterior to ŏotype, mostly intercaecal.

Discussion —The new form as will appear from the description belongs to the family Gorgoderidae and the subfamily Gorgoderinae. It differs from all the known genera of the subfamily (*Gorgodera, Phyllodistomum, Macia* and *Xystretum*) in the possession of funnel-shaped buccal cavity, in the position of the genital pore, in the shape of the excretory bladder, in the number and configuration of the testes *Gorgodera* is the only genus in which the number of testes is more than two, but in *Gorgodera* the testes are nine in number and are arranged in two longitudinal rows one behind the other, one row consisting of four and the other of five testes. In *Gorgotrema* the testes are in large numbers (34—40) scattered irregularly in the anterior half of the broad portion of the body The difference in the number and the configuration of the testes, the position of the genital pore, and the possession of the buccal-funnel is enough to justify the erection of a new genus, with the following diagnosis —

Gorgoderinae, with flat body divided into an anterior narrow elongated portion and a posterior expanded, nearly circular portion Cuticle covered with small scattered spines A funnel-shaped buccal cavity present, pharynx absent, œsophagus long, intestinal caeca simple and broad Excretory bladder tubular and with lateral branches Genital pore anterior to intestinal bifurcation, a genital atrium is present. Testes follicular, scattered in the anterior half of the broad portion of the body Ovary on the right side internal to the intestinal caecum, and at the same level as the vitelline glands Vitelline glands two and unbranched Uterine coils mainly intercaecal and behind the ootype Eggs oval with thin light-brown shell Parasites of the urinary organs of fishes

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THE FATE OF THE DUCT OF CUVIER IN MAN AND CERTAIN OTHER MAMMALS

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SUMMARY

The large venous trunks in the case of man and 11 types of Mammals have been investigated. The arrangement of veins in the region of the superior vena cava and the coronary sinus has been described. As a result of this investigation it is observed that three definite types of arrangement exist and these have been discussed from the developmental point of view.

The big veins entering the right atrium in man and several mammals have been dissected and studied, and an attempt has been made in this paper to compare the varying conditions of these veins and discuss the possible origin of these variations. As far as possible, the animals were obtained alive, they were narcotised with chloroform and dissected in fresh condition. In the case of smaller animals, preserved parts were used and the veins were injected with methylene blue.

The subjects and their number used during the course of this investigation were —

Human	5	Rabbit	2
Monkey	3	White Rat	3
Goat	2	Porcupine	2
Sheep	1	Mongoose	2
Dog	2	Squirrel	3.
Fox	1	Cat	2

As a result of these investigations it was found that the arrangements in connection with the formation of the *superior vena cava* and the *coronary sinus* fall into three main groups —

(1) *The arrangement, as is found typically in man,* consists of (*a*) a single superior vena cava on the right side with the azygos vein opening into it, and (*b*) a coronary sinus on the left side. This arrangement was found to be constantly present in the monkey, dog, cat, and fox (fig 4).

(2) *The arrangement, as is found typically in rodents,* consists of (*a*) a superior vena cava on each side, and (*b*) the azygos vein opening into the superior vena cava of the right side (fig 6)

(3) *The arrangement, as is found in goats and sheep*, consists of (*a*) a right superior vena cava without the azygos vein, and (*b*) a left azygos vein which opens directly into the right atrium, and replaces the coronary sinus in man and the left superior vena cava in Rodents (fig 5)

DEVELOPMENT OF THE VENOUS SYSTEM IN EARLY STAGES

In its earlier stages the venous system consists of two *anterior cardinal veins* and two *posterior cardinal veins* which join together to form the *common cardinal vein* of either side. The common cardinal veins receive the umbilical and vitelline veins and thus form the *duct of Cuvier* on either side (fig 1) This arrangement of veins forms the ground plan of the embryonic venous system in all mammals The different types of the adult venous system are obtained by the formation of fresh cross-channels between the embryonic veins, and the atrophy and obliteration of some of these veins

(1) *Subsequent Development in Man* —In man, a cross-channel appears between the two anterior cardinal veins On the right side, part of the anterior cardinal vein, lying proximally to this new cross-channel, forms the superior vena cava, the cross-channel itself forming the left innominate vein The superior vena cava in its lowest part is formed by the duct of Cuvier The posterior cardinal vein persists on this side and forms the uppermost portion of the azygos vein which opens into the superior vena cava. On the left side, however, the intra-pericardial portion of the left anterior cardinal vein and the duct of cuvier undergo partial atrophy and give rise to the vestigial fold and the oblique vein of Marshall. This oblique vein turns round the left auricle to terminate into the left horn of the sinus venosus, which is the precursor of the coronary sinus The left posterior cardinal vein atrophies

To sum up, the adult condition in man consists of (1) a superior vena cava on the right side, formed from the right anterior cardinal vein and the right duct of Cuvier, (2) the azygos vein formed from the right posterior cardinal vein and opening into the superior vena cava, and (3) the coronary sinus on the left side (fig 4)

Since the adult venous system in man resembles that found in the dog, cat, fox and monkey, it is likely that the venous system in these animals follows the same course of development as in man

(2) *Subsequent Development in Rodents* —In Rodents both the right and left anterior cardinal veins persist and form the two superior vena cavae In their proximal parts, both the superior vena cavae are completed by the ducts of Cuvier and finally open into the right atrium.

The right posterior cardinal vein also persists and gives rise to the proximal portion of the azygos vein On the left side, the posterior cardinal vein atrophies

Thus we have in the adult (1) the right superior vena cava formed from the right anterior cardinal vein and the right duct of Cuvier, (2) the left superior vena cava formed from the left anterior cardinal vein and the left duct of Cuvier, and (3) the azygos vein formed from the posterior cardinal vein and opening into the right superior vena cava. The left superior vena cava winds round the lower border of the heart and, after traversing the auriculo-ventricular groove, opens into the right atrium close to the opening of the inferior vena cave (fig 6)

(3) *Subsequent Development in Goats and Sheep* —A cross-channel develops between the two anterior cardinal veins and forms the left innominate vein as in the case of man The part of right anterior cardinal vein, lying proximally to the cross-channel, forms the distal portion of the superior vena cava, the proximal portion being formed by the duct of Cuvier The left anterior cardinal vein proximal to the cross-channel atrophies. The posterior cardinal vein of the right side atrophies, while that of the left side persists and forms a part of the azygos vein which in its subsequent course is completed by the left duct of Cuvier and opens finally into the right atrium

Thus we have in the adult (1) a superior vena cava formed from the right anterior cardinal vein and the duct of Cuvier, (2) a left azygos vein formed from the left posterior cardinal and the left duct of Cuvier The azygos vein lies on the left side of the descending aorta and winds round the superior aspect of the left root of the lung and then traverses the atrio-ventricular groove Finally it opens independently into the right atrium, the opening being placed close to the left side of the opening of the inferior vena cava (fig 5).

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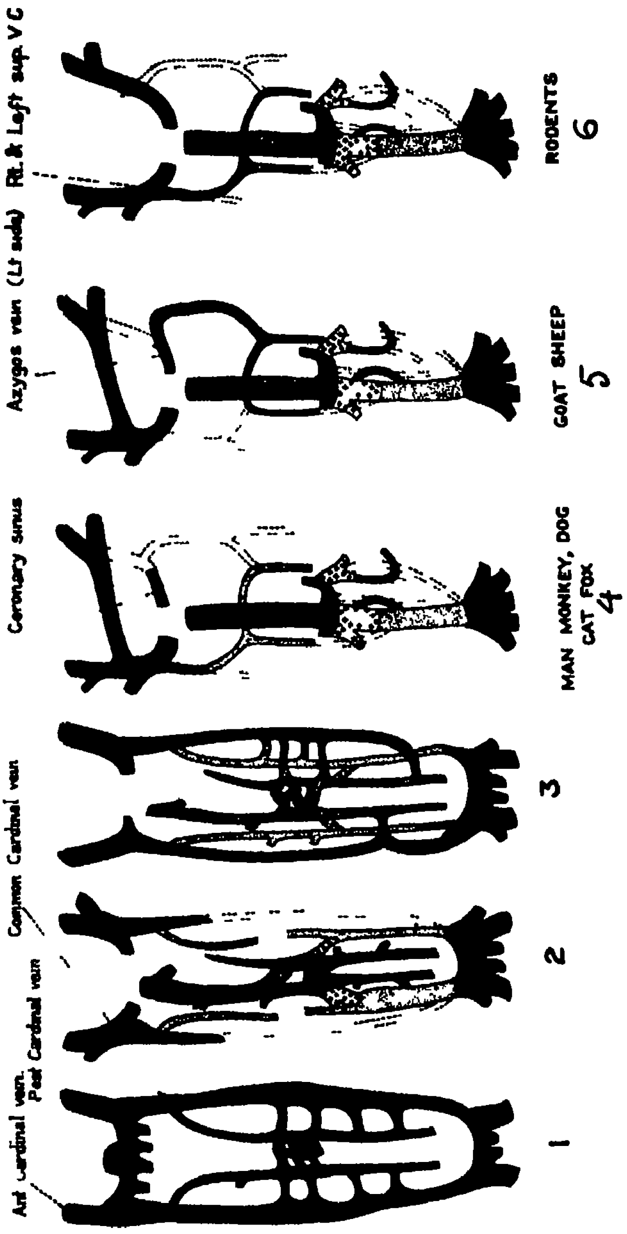
M. A. H. Siddiqi and R. V. Singh—The Fate of the Duct of Cuvier in Man and certain other Mammals



Figs. 1, 2 and 3 illustrate the earlier stages in the development of the systemic venous system in man. Fig. 4 illustrates the final stage in man, monkey, dog, cat and fox. Fig. 5 illustrates the final stage in goats and sheep. Fig. 6 illustrates the final stage in Rodents.

CERTAIN MODIFICATIONS OF DEDEKIND'S THEOREM OF CONTINUITY

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Communicated by Dr P L Srivastava

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SUMMARY

In this paper Mahajani's and Bromwich's modifications of Dedekind's treatment of Real Numbers are examined and a different one suggested

Dedekind's Section of the Rational Numbers R is defined by him as follows — "If now *any separation of the system* R into two *classes* A_1, A_2 is *given* which possesses only this characteristic property that every number a_1 in A_1 is less than every number a_2 in A_2, then for brevity we *shall call such a separation* a cut (Schnitt) and designate it by (A_1, A_2) "[2] Three possibilities follow from this section of the Rationals —(*i*) A_1 has a greatest or (*ii*) A_2 has a least or (*iii*) neither A_1 has a greatest nor A_2 a least. Obviously (*i*) and (*ii*) cannot occur simultaneously In case (*i*) or (*ii*) occurs, the greatest number in A_1 or the least in A_2 is a rational number and is defined by the cut, (A_1, A_2) When (*iii*) occurs, Dedekind introduces the Axiom of Continuity and the Irrational number x is created corresponding to the cut (A_1, A_2) The Rational and Irrational numbers defined by the cut (A_1, A_2) of the Rationals are called Real Numbers and denoted by R Order in the set is then set up by three *definitions*, which *may be taken* as three conditions, *i.e*, it is established how and when $x >/< y$ He then establishes his famous *Theorem of Continuity* for the Real Numbers R [1] —

"If the system R of all real numbers breaks up into two classes A_1, A_2 such that every number x_1 of A_1 is less than every number x_2 of A_2 then there exists one and only one number x, by which this cut is produced."

The power of Dedekind's Theorem of Continuity lies in the following facts — (1) All real numbers $(G_1 \leq x \leq G_2)$ are classified (2) There are just two classes—not more not less (3) The theorem is true in any interval of Real Numbers, closed or open (4) The division into two classes is brought about by any method whatsoever of division (5) There is one and only one condition on which this theorem is established, aside from the three, used for introducing 'order' It is for these reasons that it is so widely and powerfully applied in Analysis

MAHAJANI'S MODIFICATION

Let us now consider Mahajani's modification of Dedekind's treatment of the Irrational Number This is in the form of *five* conditions instead of the *one* required by Dedekind He states, "Try to separate the rational numbers into two classes—the lower class and the upper class (a/A)—so that they satisfy the five conditions, mentioned above,"[5] which are as follows —

> "(i) if a belongs to the lower class so does every number less than a,
> (ii) if A belongs to the upper class so does every number greater than A,
> (iii) every number a is less than every number A,
> (iv) numbers a and A can be found in the two classes such that (A-a) is less than any arbitrary fraction,
> (v) neither the lower class (a) has a greatest nor the upper class (A) has a least "[5]

Later three definitions in the nature of conditions are introduced to establish order, thus making eight conditions in all The number of conditions imposed in a Theorem is a very important matter In general the greater the number of conditions, the more limited is its application The proof, however, may become simpler Let us therefore examine the five conditions leaving aside the three on 'order'

Condition (iii) is the same as Dedekind's

Conditions (i), (ii), (iv) cannot be called conditions if by a 'condition' we mean some quality which if not stated and demanded is not necessarily true But these are easily deducible from the properties of Rational numbers and condition (iii) Hence whether these are stated or not stated nothing is lost so far as the Theorem is concerned

Condition (v) is the only real modification, hence its effect on the theorem must be examined carefully (1) This condition is inserted to ensure "that all the rational numbers *except one* are here classified "[6] It is again stated in connection with this modification, "Separate the rational numbers into two classes"[6] But if one number always escapes classification, it is not a classification of all the Rational numbers, it is a classification of all but one and this one forms a class by itself There are in fact three classes Now the division of the Rational numbers (or of Real Numbers) into two classes is to be effected in de la Vallee Poussin's words "par un procede quelqonque"[10] whereas in Mahajani's modification, it can be produced only if a number is specified In the problems that arise in Analysis where this theory is applied we are generally forced to rely upon two properties say P and Q which, as, Hardy puts it, "are mutually exclusive and one of which must be possessed by *every* rational number"[4] *As a result no rational number can escape classification and only two classes can arise.* (2) Condition (*v*) is however *one* of the possibilities resulting from the section of Rational Numbers into two classes 'par un procede quelqonque,' and when this possibility occurs, the Irrational Number is introduced to preserve the idea of continuity attached to the aggregate of points forming a straight line Hence it is difficult to see how (*v*) can be considered as a condition (3) In dealing with numbers, the separation into classes is limited to finite numbers, hence the set (x) is bounded above and below, that is to say $G_1 \leq x \leq G_2$, or, x is defined over a *closed* interval It is, however, obvious that this modification *cannot be applied to the two end numbers* (4) Notice again that in dealing with the four operations between any two numbers Mahajani removes all negative numbers from the lower classes "thus leaving these classes truncated during the operation" But in the truncated classes thus produced, the proof is not valid when one of the numbers is zero (5) It is however when condition (*v*) is applied to *Real Numbers* that a more serious defect is introduced It is stated in connection with the proof of the Theorem of Continuity of Real Numbers that "if a/A is a section of the *Reals* satisfying the *five* conditions,"[7] and "One *real number* must always escape classification," [8] and again "By modifying Dedekind's method in the way here adopted—we *always* get an *open* cut"[8] That is to say, according to Mahajani's definition of the 'Section' of the Real Numbers *also* it is required that the lower class should have no greatest number and the upper class no least and that one number should always escape classification It follows, however, from the nature of the two properties P and Q quoted above that *all* numbers in the closed interval $G_1 \leq x \leq G_2$ of Real numbers are classified into two classes and consequently *one* of the sections must be closed Unless this happens the theorem is not applicable in Analysis. This is confirmed by the following fact —

The very first theorem in Analysis to which the Theorem on Continuity is applied by Mahajani is in the Theory of Limits, to prove 'the existence of a least among all upper bounds of an aggregate'[9] In proving this theorem Mahajani does not use his own modification of Dedekind's section of Real Numbers, but applies Dedekind's method I quote from Mahajani[9] —

> "All Real Numbers are now classified in this mode of partition and we have a Dedekind section, whose upper class consists of the upper bounds of (x)
>
> Observe now that it is impossible in this case for the lower class to possess a greatest number .
>
> It follows, therefore, that as the lower class of the Dedekind section has no greatest, the upper class must possess a least."

Note that here Mahajani is laying emphasis on the last sentence, that is to say, one of the classes *must* be closed, hence *both are not open*. This is contrary to condition (*v*). This is precisely the weakness in Mahajani's modification of Dedekind's Theorem as applied to Real Numbers.

BROMWICH'S MODIFICATION

Mahajani[6] states "Bromwich omits the fifth condition which appears to be essential." As a matter of fact, Mahajani's first four conditions are exactly the same as Bromwich's[1] four conditions and the fifth is also implied by Bromwich. In fact Bromwich states in connection with his modified form of Dedekind's definition "Suppose that a classification of the Rational Numbers has the following properties —

(1) If a belongs to the lower class, so does every rational number less than a.

(2) If A belongs to the upper class, so does every rational number greater than A,

(3) every number a is less than every number A,

(4) numbers A, a can be found in the two classes such that A-a is less than an arbitrary rational fraction.

Such a classification defines a single number, rational or irrational. For any rational number 'r' which does not belong to either class must lie between the two classes. Consequently not more than one rational number can escape classification. If there is one such number, the classification may be regarded as defining that number, but if there is no rational number which escapes classification we have obtained a Dedekind section and have therefore defined an irrational number."[1]

The definition of the section and the axiom in regard to irrational numbers must lead to the Theorem of Continuity of the Real Numbers, that is, if the section is applied to Real Numbers, one and only one real number should exist which is either the greatest in the lower class or the least in the upper. It is this theorem which is applied in Analysis. Bromwich has not utilised his modification to establish this Theorem. His section of Rational Numbers allows the possibility of one Rational Number escaping classification. Hence his section also could not be applied to the problems that arise in Analysis.

DEFINITION OF THE SECTION OF RATIONAL NUMBERS AND AXIOM OF CONTINUITY

The following treatment of Dedekind's Theory (which in essence is the same as Dedekind's) is given, in which only *two* conditions are used to establish the set of Real Numbers, 'order' it, and to prove the Theorem of Continuity of Real Numbers.

(C≡contained in)

Given any arrangement by which the set of Rational Numbers (r), ($G_1 \leq r \leq G_2$), is divided into two classes (in the sense, not more nor less), (r_1) and (r_2) such that every r_1 C (r_1) < every r_2 C (r_2), then either

(1) there exists a (in the sense, one and only one) Rational Number R_{12} such that

$$(i)\quad r_1 \leq R_{12} < r_2$$

$$\text{or}\quad (ii)\quad r_1 < R_{12} \leq r_2$$

or (2) no such rational exists, in which case we introduce the Irrational number R'_{12} such that (*Axiom of Continuity*)

$$r_1 < R'_{12} < r_2$$

The numbers R_{12} and R'_{12} together form the set of Real Numbers R or (x) The following Theorems are easily deducible —

(1) The set R is 'ordered'

(2) (Dedekind's Theorem of Continuity) Any separation of R into two classes (x_1) and (x_2) such that every $x_1 < x_2$, produces no discontinuity, *i e* one and only one Real Number x_{12} exists by which this separation is produced, such that it is either the greatest of the lower class or the least of the upper The advantages of this method consist—

(1) in that the number of conditions is reduced to only two,

(2) (and perhaps also) in the simple manner in which the definition of the section and the axiom are stated here

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NEW AVIAN TREMATODES (FAMILY DIPLOSTOMIDAE) FROM INDIAN BIRDS

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SUMMARY

Four new species of avian trematodes belonging to the family Diplostomidae have been described in this paper

1 *Posthodiplostomum botauri* n sp (Fig 1)

Host *Botaurus stellaris*, small intestine.

Locality Allahabad, U P, India

Body 1 248-1 446 in length Forebody flattened with foliate lateral margins slightly incurved ventrally, 0 72-0 992 long and 0 7-0 72 broad, hindbody cylindrical, broad in the centre and narrow at the two ends, nearly half the length of forebody, measuring 0 48-0 57 × 0 256 0 386 in size Suckers feebly developed and spherical Oral sucker terminal, 0 03-0 04 in diameter Acetabulum, 0 48 in diameter, situated close behind middle third of forebody Holdfast organ 0 128-0 176 long, 0 224-0 228 broad, elliptical in outline, and situated 0 121 behind acetabulum Adhesive gland, composed of two cellular masses, situated posterodorsal to holdfast organ Prepharynx very short, 0 01 in length, pharynx, 0 03 0 045 long and 0 036-0 046 broad Oesophagus fairly long, 0 084-0 102, intestinal caeca pass ventrally over gonads in hindbody and terminate a little in front of genital atrium

Gonads in anterior two-third part of hindbody Anterior testis a symmetrical and wedge-shaped, 0 144-0 176 long and 0 192-0 24 broad, situated in left half, posterior testis symmetrical, roughly horseshoe-shaped with the two limbs directed anteriad, measuring 0 156-0 32 in length and 0 096 in breadth Mehlis gland and vitelline reservoir intertesticular Vesicula seminalis feebly developed, slightly coiled and situated posterodorsal to second testis Ovary 0 064-0 096 long and 0 096-0 128 broad, in anterior quarter of hindbody, usually a little nearer left than right. Uterus extends forwards to near body constriction, the narrow terminal portion

of the descending limb along with distal part of the ejaculatory duct, opens at the apex of the genital cone Bursa copulatrix prominent 0 116-0 15 long and 0·23-0 30 broad, more or less cup-shaped but incomplete ventrally, enclosing the

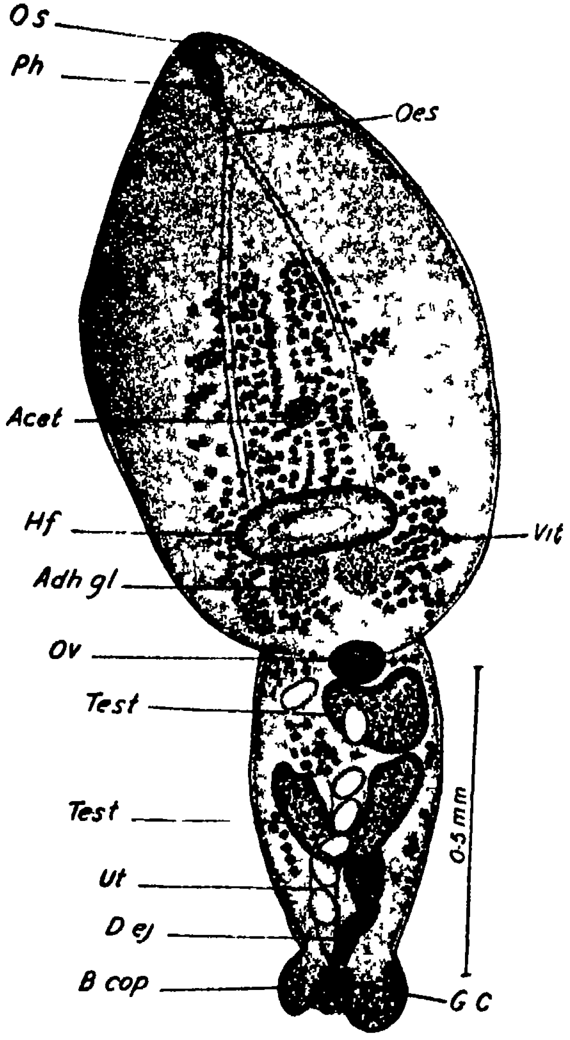

Fig 1

Posthodiplostomum botauri n sp

Acet, Acetabulum, ***Adh gl.***, adhesive gland, ***B cop***, Bursa copulatrix ***D ej***, Ductus ejaculatorius, ***Ej.p***, Ejaculatory pouch, ***G a*** Glandular area ***G C*** Genital cone, ***G p***, Genital pore, ***Hf*** Holdfast organ, ***Int***, Intestinal caecum ***O S*** Oral sucker, ***Oes***, Oesophagus, ***Ov***, Ovary, ***Ph***, Pharynx, ***Test***, Testis, ***Ut***, Uterus, ***V sem***, Vesicula seminalis ***Vit***, Vitellaria, ***Vit res***, Vitelline reservoir centrally situated genital cone of 0 116 × 0 06 size Vitellaria follicular, extending anteriorly to about midway between acetabulum and intestinal fork and posteriorly to sub-caudal region, follicles sparsely distributed in hindbody Ova yellowish operculate and 0 08 × 0 064 in size, *i.e*, a little smaller than ovary

Remarks —The present species differs from *P grande* (Diesing 1850) Dubois 1936, *P impraeputiatum* Dubois 1934, and *P microsicya* Dubois 1936 in size of the body, ratio in the length of fore and hind parts, and in the form size and position of the gonads It is separated from *P minimum* (MacCallum, 1921) Dubois 1936, on account of the large size of the body and the suckers, and the topography of the genital organs The species, *Neodiplostomum orchilongum* Noble 1936, is assigned to the genus *Posthodiplostomum* Dubois on account of the presence of a prominent bursa copulatrix—a feature which alone distinguishes it from the closely allied genus *Neodiplostomum* The new species *P botauri* n sp stands closest to *P cuticula* (v Nordmann) and *P orchilongum* (Noble, 1936) on account of the form and size of the body, location of the acetabulum, and position of the gonads It, however, differs from them in the position and shape of the testes, extent and concentration of the vitelline follicles and size of the ova

2 *Neodiplostomum mehraianum* n sp (Fig 2)

Host *Haliaeetus leucoryphus*, small intestine.

Locality Allahabad, U P, India.

Body, 5-6 long, distinctly marked off into fore and hind parts and armed with minute backwardly directed spines from anterior end to the level or the ovary Forebody 2 4-2 9 long, 1 253-2 5 broad, pyriform with lateral margins in-rolled ventrally and united behind holdfast organ Hindbody club-shaped, 2 23-2 97 long with maximum width of 1 23-1 34 across the sub-caudal region and shortest width of 0 48-0 8 just in front of ovary

Suckers feebly developed. Oral sucker terminal, broader than long and 0 05-0 07 × 0 09-0 11 in size Acetabulum spherical, 0 1-0 11 in diameter and situated a little in front of middle of forebody Holdfast organ prominent, highly protrusible, elliptical in outline and a little more than one-third as long as forebody, measuring 0 8-0 867 × 0 56-0 72 in size Adhesive gland situated posterodorsal to holdfast organ Prepharynx extremely small, 0 034 long, visible in sections only Pharynx oval, elongated, 0 072-0 116 × 0 07-0 11 Oesophagus 0 016-0 02 long, caeca simple, ending blindly with swollen ends a little in front of genital pore

Testes tandem, postovarian, transversely elongated and slightly constricted in the middle, with their ends bent ventrally, measuring 0 35-0·48 × 0 835-0 98 in size Vesicula seminalis feebly developed, post-testicular Genital pore median and dorsal, near posterior end of body Ovary transversely ovoid, situated a little behind body constriction, measuring 0 2-0 35 long and 0 416-0 536 broad Ootype complex intertesticular Vitellaria profuse in both body regions, extending from midway between acetabulum and pharynx to genital pore, vitelline follicles small and

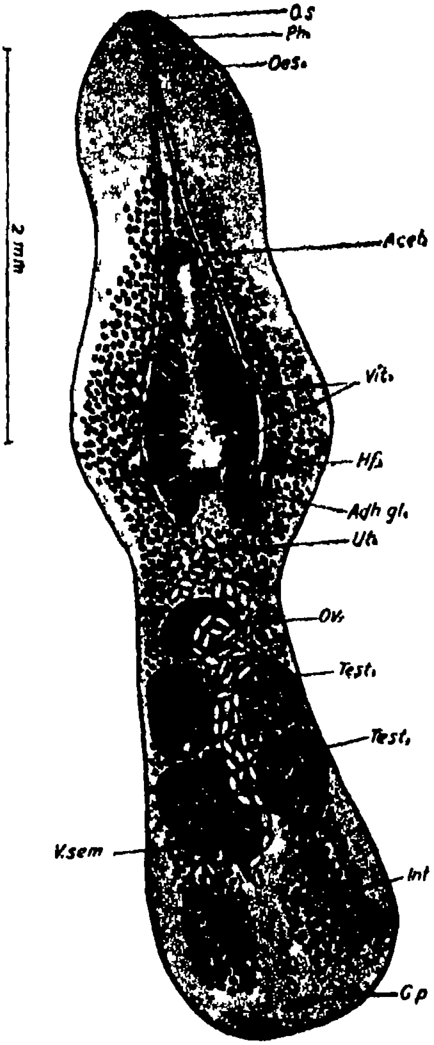

Fig 2

Neodiplostomum mehrainum n sp Lettering same as in Fig 1

spherical in front of and laterally to holdfast organ but those overlapping the latter are large, massive, transversely elongated and arranged parallel to one another.

Vitelline follicles in hindbody disposed in two broad longitudinal areas, one on each side of uterus Uterus well developed, extending anteriorly to body constriction Eggs oval, yellowish, thin-shelled and operculate, 0 0334-0 05 × 0·084 in size.

Remarks — The new species differs from *N spathulaeforme* (Brandes, 1891) Railliet 1919, and *N spathula* (Creplin, 1829) La Rue 1926, in possessing a holdfast organ without papillated internal margin In the peculiar shape and large size of the body and presence of a singularly small acetabulum it differs from *N kashmirianum* Faust 1927 *N cochleare* (Krause, 1915) La Rue 1926, *N attenuatum* (v Linstow, 1906) La Rue 1926, *N pseudoattenuatum* (Dubois, 1927) Yamaguti 1934, *N perlatum* Ciurea 1929, *N lucidum* La Rue and Bosma 1927, *N butasturinum* (Tubangui, 1932) Dubois 1936, and *N tytense* Patwardhan 1935 It is separated from *N aluconis* Tubangui 1933, on account of the much smaller size of the body, difference in the ratio in length of fore and hind parts and from *N pseudospathula* (Brandes, 1890) Ciurea 1928, and *N paraspathula* Noble 1936, in the form and size of the body, distribution of the vitelline follicles, presence of the cuticular spines and larger size of the gonads The account of the two Russian species, *N fungiloides* Semenow 1927, and *N morchelloides* Semenow 1927, is not available to me

3 *Neodiplostomum laruei* n. sp (Fig 3)

Host *Sarcogyps calvus*, small intestine

Locality Allahabad, U P., India

Body 2 528-3 79 long and distinctly divided into fore and hind parts Cuticle armed with very minute spines from anterior end to the level of the acetabulum. Forebody flattened with lateral margins inrolled ventrally and united behind holdfast organ, measuring 1 056-2 064 in length and 1 04-1 712 in width Hindbody cylindrical, nearly as long as forebody, measuring 1 312-1 712 × 0·8 in size. In some abnormal specimens the forebody has 1—12 small, spherical, glandular areas of 0 08-0 192 diameter, which lie in dense mass of vitelline follicles, holdfast organ, or on the foliate lateral margins. Oral sucker spherical, terminal and 0 08 in diameter Acetabulum transversely oval, partly covered with vitelline follicles, 0·08-0 092 in length, 0 096-0 144 in width and situated medially at the end of anterior-third of forebody Pharynx barrel-shaped, 0 096-0 128 × 0 064-0 096 in size. Oesophagus 0 05-0 08 long , intestinal caeca simple terminating with swollen ends a little in front of genital pore. Holdfast organ elongate oval, 0 448-0 8 × 0 32-0 59 in size and situated 0 18 behind acetabulum

Testes tandem, immediately post-ovarian Anterior testis somewhat wedge-shaped, 0 32-0 368 × 0 544-0 912 in size , posterior testis more or less dumb-bell-shaped, 0·288-0 416 × 0 544-0 902 Vesicula seminalis S-shaped, situated posterodorsal to holdfast organ Ovary sub-median, transversely elongated, 0·2-0·24 × 0·352-0 6

in size and situated close behind body constriction Ootype complex intertesticular Vitellaria well developed, especially in forebody where the vitelline follicles are extensively distributed, extending to near midway between acetabulum and pharynx, in hindbody vitelline follicles occupy most of the space not otherwise occupied by the reproductive organs, reaching to near the genital pore Eggs yellow, thin-shelled and operculate measuring 0 096 × 0 048 in size

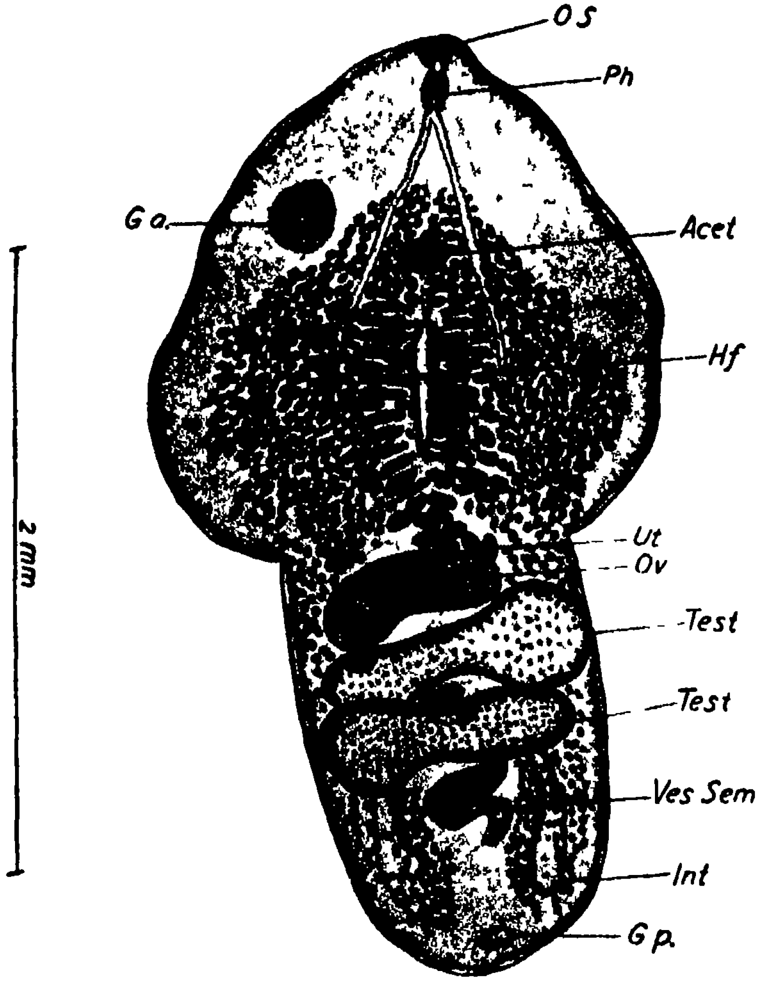

Fig 3

Neodiplostomum laruei n sp Lettering same as in Fig 1

Remarks —Of all the species *N laruei* n sp stands nearest to *N tytense* Patwardhan 1935, on account of the shape and size of the body, position of the acetabulum and the general topography of the genital organs It, however, differs from it in the extent of the vitellaria, shape and size of the holdfast organ, size of the gonads, position of the genital pore As Patwardhan describes the species from only one immature specimen, the size of the ova could not be compared

4 *Crassiphiala ceryliformis* n sp (fig 4)

Host *Ceryle rudis leucomalanura*, small intestine.

Locality Allahabad, U P, India

Body 1 44-1 648 in length and distinctly divided into fore and hind parts Forebody short, urn-shaped, feebly muscular, 0 32-0 416 in length and 0 270-0 32 in maximum width across holdfast organ Hindbody cylindrical, nearly three times as long as forebody, measuring 1 12-1 232 in length and 0 272-0 32 in width Oral sucker small and terminal, 0 0175-0 025 long and 0 024-0 025 broad Acetabulum absent Holdfast organ intercaecal, elliptical or spherical in outline, 0 096-0 112 in diameter and situated a little behind equator of forebody Adhesive gland cells diffused around holdfast organ Pharynx longer than broad, 0 021 × 0 018-0 023 Oesophagus 0 039-0 045 long Intestinal caeca simple, extremely thin walled and narrow, passing laterally and dorsally to holdfast organ, curving ventrally in hindbody and extending along ventral body wall to posterior margin of second testis

Gonads in posterior two-third part of hindbody Testes tandem, post-ovarian and massive Anterior testis kidney-shaped, 0 176-0 224 long and 0 208 broad, posterior testis larger, broadly bilobate and 0 280-0 290 × 0 192 in size Vesicula seminalis large slightly coiled, situated behind second testis. Ejaculatory pouch prominent Ovary 0 064-0 08 × 0 08-0 088, oval to spherical in outline, situated nearer right side and definitely dorsal in position Ascending uterus passes to left side of ovary, makes an abrupt loop ventrally to left side at about midway between ovary and body constriction and then bends to continue backwards as descending uterus along ventral body wall Genital cone present. Genital atrium small, enclosing a muscular genital bulb Genital pore terminal Vitellaria profuse, exclusively confined to hindbody, extending from body constriction to half the length of ejaculatory pouch and especially concentrated in extracaecal areas. Ova yellowish, operculate 0 04-0 08 in size

Remarks —The new species differs from *Crassiphiala denticulata* (Rudolphi, 1819) Dubois 1932, *C gracilis* (Yamaguti, 1934) Dubois 1934, and *C cochleariformis* (Yamaguti, 1934) Dubois 1934, in smaller size of the body and the oral sucker, absence of the acetabulum, more forward position of the gonads, smaller size of the

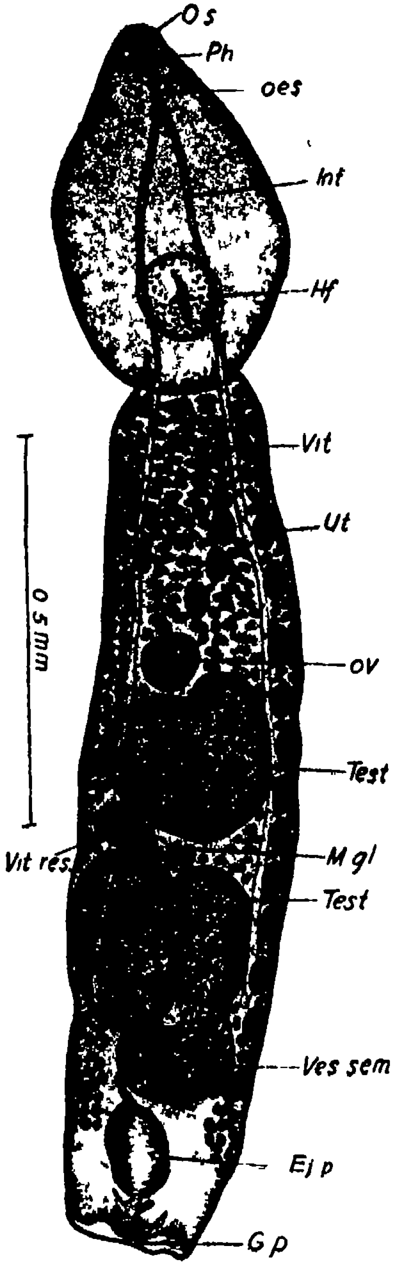

Fig 4

Crassiphiala ceryliformis n sp Lettering same as in Fig 1 ova, and in the anterior limit of the vitellaria but in the latter character from the first two species only. It is separated from *C ambloplitis* (Hughes, 1927) Hunter 1933, on account of the smaller size of the body, absence of the 'neck region' and acetabulum and the smaller size of the ova. *C. ceryliformis* n. sp. stands closest to *C bulboglossa* v Haitsma 1925, on account of the absence of the acetabulum position of the gonads in the posterior two-third part of the hindbody and the extent of the vitellaria, but differs in the form of the body, difference in the ratio in the length of fore and hind parts and larger size of oral sucker, pharynx and ova

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THE SOLUTION OF CERTAIN TYPES OF DIFFERENTIAL EQUATIONS

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SUMMARY

In this paper, the Differential Equations

$$\frac{d^2y}{dx^2}+y-c^2x^ny=0$$

and

$$\frac{d^2y}{dx^2}+y-4\beta^2c^2x^2e^{2\beta x^2}y=0$$

have been solved In case of the second equation the different cases arising by taking different signs of β and c have been dealt with at length and the corresponding primitive in each case is given separately

1 There are two types of differential equations, namely,

$$(1)\quad \frac{d^2y}{dx^2}+y-c^2x^ny=0$$

and

$$(2)\quad \frac{d^2y}{dx^2}+y-4\beta^2c^2x^2e^{2\beta x^2}y=0$$

where c and β are constants, which may have wide application in Theoretical Physics

Equations of the type

$$\frac{d^2y}{dx^2}-c^2x^ny=0$$

have been solved by A R. Forsyth and others by means of Definite Integral method We may now generalise the method and obtain the solutions for the equations given above It is believed that the solutions of the equations of these types have not been obtained before.

2. Let us take the equation

$$\frac{d^2y}{dx^2}+y-c^2x^ny=0$$

To solve this, let us assume

$$y=\int e^{-pt}\,P\,dp,$$

where t denotes an unknown function of x alone and P an unknown function of p alone, both of these functions and the limits of integration have to be determined

Differentiating the value of y twice with respect to x and substituting in the equation, we find

$$\int e^{-pt}\,\mathrm{P}\left[p^2\left(\frac{dt}{dx}\right)^2+1-c^2x^n\right]dp-\int e^{-pt}\,\mathrm{P}\,p\,\frac{d^2t}{dx^2}\,dp=0 \tag{1}$$

Choose the unknown function t such that

$$\left(\frac{dt}{dx}\right)^2=c^2x^n$$

This gives

$$t=\frac{c}{\tfrac{1}{2}n+1}\,x^{\frac{1}{2}n+1}=\frac{c}{m}\,x^m,\ \text{where } m=\tfrac{1}{2}n+1$$

The equation (2), after multiplying by $\frac{x^2}{mt}$ and substituting the values of $\frac{dt}{dx}$ and $\frac{d^2t}{dx^2}$, becomes

$$m\int e^{-pt}\,\mathrm{P}\,(p^2-1)\,t\,dp+\frac{x^2}{mt}\int e^{-pt}\,\mathrm{P}\,dp-(m-1)\int e^{-pt}\,\mathrm{P}p\,dp=0 \tag{2}$$

Integrating the first term in (2) by parts and rearranging the terms we get

$$-\Big[e^{-pt}\,m\mathrm{P}\,(p^2-1)\Big]+\int e^{-pt}\left[m\,\frac{d}{dp}\Big\{\mathrm{P}\,(p^2-1)\Big\}+\frac{x^2}{mt}\,\mathrm{P}-(m-1)\,\mathrm{P}p\right]dp=0 \tag{3}$$

The equation (3) will be identically satisfied if we put

$$m\,\frac{d}{dp}\Big[\mathrm{P}\,(p^2-1)\Big]+\frac{x^2}{mt}\,\mathrm{P}-(m-1)\,\mathrm{P}p=0 \tag{4}$$

for all values of p included between the limits of integration given by

$$\Big[e^{-pt}\,\mathrm{P}\,(p^2-1)\Big]=0 \tag{5}$$

On slight reduction (4) becomes

$$\frac{d\mathrm{P}}{\mathrm{P}}=-\frac{1}{m}\left[\frac{m+1}{2}\,\frac{2p}{p^2-1}+\frac{x^2}{2mt}\,\frac{2}{p^2-1}\right]dp$$

Solving the above equation we get

$$\mathrm{P}=\mathrm{A}\,(p-1)^{-\left\{\frac{m+1}{2m}+\frac{x^2}{2m^2t}\right\}}(p+1)^{-\left\{\frac{m+1}{2m}-\frac{x^2}{2m^2t}\right\}},$$

A, being an arbitrary constant and (5) on substitution becomes

$$e^{-\frac{c}{m}x^m p}\,(p-1)^{1-\left\{\frac{m+1}{2m}+\frac{x^2}{2m^2t}\right\}}(p+1)^{1-\left\{\frac{m+1}{2m}-\frac{x^2}{2m^2t}\right\}}=0,$$

which on solving gives three roots, namely,

$$p=\infty,\ p=1 \text{ and } p=-1$$

provided

$$1-\frac{m+1}{2m}-\frac{x^2}{2m^2t}>0 \qquad (6)$$

and

$$1-\frac{m+1}{2m}+\frac{x^2}{2m^2t}>0 \qquad (7)$$

On simplification (6) and (7) become respectively

$$x^{\frac{1}{2}n-1}>\frac{2}{nc}$$

and

$$x^{\frac{1}{2}n-1} > -\frac{2}{nc}$$

But if n and c are both positive and x is positive the latter condition is contained in the former

Now the solution the equation will be

$$y=A_1\int_{-1}^{1}e^{\lambda}\,(p-1)^{\mu}\,(p+1)^{\nu}\,dp+B_1\int_{1}^{\infty}e^{\lambda}\,(p-1)^{\mu}\,(p+1)^{\nu}\,dp,$$

where

$$\lambda=-\frac{2cpx^{\frac{1}{2}n+1}}{n+2},$$

$$\mu=\frac{-1}{2(n+2)}\left\{n+4+\frac{2}{c}x^{1-\frac{1}{2}n}\right\},$$

$$\nu=\frac{-1}{2(n+2)}\left\{n+4-\frac{2}{c}x^{1-\frac{1}{2}n}\right\},$$

n, c and x being positive and these three quantities are connected by the relation

$$x^{\frac{1}{2}n-1}>\frac{2}{nc}.$$

3 We shall now take the equation

$$\frac{d^2y}{dx^2}+y-4\beta^2c^2x^2e^{2\beta x^2}\,y=0$$

To solve this, let us assume as before

$$y=\int e^{-pt}\,P\,dp,$$

where t denotes an unknown function of x alone and P an unknown function of p alone, both of these functions and the limits of integration have to be determined.

Differentiating y twice and substituting in the equation, we get

$$\int e^{-pt}\mathrm{P}\left[p^2\left(\frac{dt}{dx}\right)^2+1-4\beta^2c^2x^2e^{2\beta x^2}\right]dp-\int e^{-pt}\,\mathrm{P}p\frac{d^2t}{dx^2}dp=0 \tag{8}$$

Choose the function t such that

$$\left(\frac{dt}{dx}\right)^2=4\beta^2c^2x^2e^{2\beta x^2}$$

This gives

$$t=ce^{\beta x^2}$$

and

$$\frac{d^2t}{dx^2}=2\beta ce^{\beta x^2}\left(1+2\beta x^2\right)$$

Substituting the values of $\frac{dt}{dx}$ and $\frac{d^2t}{dx^2}$ in (8) it becomes

$$\int e^{-pt}\mathrm{P}(p^2-1)dp+\int\frac{e^{-2\beta x^2}}{4\beta^2c^2x^2}e^{-pt}\mathrm{P}dp-\int\frac{e^{-\beta x^2}(1+2\beta x^2)e^{-pt}}{2\beta cx^2}\mathrm{P}\,p\,dp=0 \tag{9}$$

Integrating the first term in (9), we get

$$-\left[e^{-pt}\,\mathrm{P}\,(p^2-1)\right]+\int e^{-pt}\frac{d}{dp}\left[\mathrm{P}\,(p^2-1)\right]dp+\int\frac{e^{-2\beta x^2}}{4\beta^2c^2x^2}e^{-pt}\mathrm{P}t\,dp$$

$$-\int\frac{e^{-\beta x^2}}{2\beta c\,x^2}\,(1+2\beta\,x^2)\,e^{-pt}\,\mathrm{P}\,pt.\,dp=0\ . \qquad . \tag{10}$$

The equation (10) will be identically satisfied if

$$\frac{d}{dp}\left[\mathrm{P}\,(p^2-1)\right]+\frac{e^{-2\beta x^2}}{4\beta^2c^2x^2}\,\mathrm{P}t-\frac{e^{-\beta x^2}}{2\beta c\,x^2}\,(1+2\beta x^2)\,\mathrm{P}pt=0\ . \qquad . \tag{11}$$

for all values of p included between the limits of integration given by

$$\left[e^{-pt}\,\mathrm{P}\,(p^2-1)\right]=0 \tag{12}$$

On slight reduction (11) becomes

$$\frac{d\mathrm{P}}{\mathrm{P}}=\left[\frac{2p}{p^2-1}\left\{\frac{1+2\beta x^2}{4\beta x^2}-1\right\}-\frac{e^{-\beta x^2}}{8\beta^2cx^2}\ \frac{2}{p^2-1}\right]dp$$

Solving the above equation we have

$$\mathrm{P}=\mathrm{A}\ (p-1)^{\left\{\frac{1-2\beta x^2}{4\beta x^2}-\frac{e^{-\beta x^2}}{8\beta^2cx^2}\right\}}\ (p+1)^{\left\{\frac{1-2\beta x^2}{4\beta x^2}+\frac{e^{-\beta x^2}}{8\beta^2cx^2}\right\}}=0,\ . \tag{13}$$

where A is an arbitrary constant. On substituting the value of P in (12) we get

$$e^{-pce^{\beta x^2}} \cdot (p-1)^{\left\{\frac{1+2\beta x^2}{4\beta x^2}-\frac{e^{-\beta x^2}}{8\beta^2 c x^2}\right\}} (p+1)^{\left\{\frac{1+2\beta x^2}{4\beta x^2}+\frac{e^{-\beta x^2}}{8\beta^2 c x^2}\right\}} = 0 \quad . \qquad (13)$$

Case A.—Taking β and c both positive, the equation (13) gives the following roots as limits

(*a*) $p=\infty$, $p=1$ and $p=-1$,

if $(1+2\beta x^2) > \frac{e^{-\beta x^2}}{2\beta c}$

(*b*) $p=\infty$ and $p=-1$,

if $(1+2\beta x^2) = \frac{e^{-\beta x^2}}{2\beta c}$

(*c*) $p=\infty$, $p=-\infty$ and $p=-1$,

if $(1+2\beta x^2) < \frac{e^{-\beta x^2}}{2\beta c}$

Case B—Taking β positive and c negative, (say) equal to $-a$ where a is positive, the equation (13) gives the following limits —

(*a*) $p=-\infty$, $p=1$ and $p=-1$,

if $(1+2\beta x^2) > \frac{e^{-\beta x^2}}{2\beta a}$

(*b*) $p=-\infty$ and $p=1$,

if $(1+2\beta x^2) = \frac{e^{-\beta x^2}}{2\beta a}$

(*c*) $p=-\infty$, $p=1$ and $p=\infty$,

if $1+2\beta x^2 < \frac{e^{-\beta x^2}}{2\beta a}$.

Case C—Taking β negative and equal to $-b$, where b is positive and c positive, (13) gives the following limits —

(*a*) $p=\infty$, $p=-\infty$ and $p=-1$,

if $\frac{e^{bx^2}}{2bc} > (1-2bx^2)$.

(*b*) $p=\infty$ and $p=-\infty$,

if $$\frac{e^{bx^2}}{2bc} \leqq (1-2bx^2).$$

Case D—Taking β negative, (say) equal to $-b$, where b is positive and c negative, (say) equal to $-a$, where a is positive, the equation (13) gives the following limits —

(*a*) $p=-\infty$, $p=1$ and $p=\infty$,

if $$\frac{e^{bx^2}}{2ab} > (1-2bx^2)$$

(*b*) $p=-\infty$ and $p=\infty$,

if $$\frac{e^{bx^2}}{2ab} \leqq (1-2bx^2)$$

Now the primitives in the different cases are given as follows —

Case A —β and c are positive

(*a*) When $(1+2\beta x^2) > \dfrac{e^{-\beta x^2}}{2\beta c}$,

$$y=A_1\int_{-1}^{1} e^{-pce^{\beta x^2}}(p-1)^{\left\{\frac{1-2\beta x^2}{4\beta x^2}-\frac{e^{-\beta x^2}}{8\beta^2 cx^2}\right\}}(p+1)^{\left\{\frac{1-2\beta x^2}{4\beta x^2}+\frac{e^{-\beta x^2}}{8\beta^2 cx^2}\right\}}dp$$

$$+B_1\int_{1}^{\infty} e^{-pce^{\beta x^2}}(p-1)^{\left\{\frac{1-2\beta x^2}{4\beta x^2}-\frac{e^{-\beta x^2}}{8\beta^2 cx^2}\right\}}(p+1)^{\left\{\frac{1-2\beta x^2}{4\beta x^2}+\frac{e^{-\beta x^2}}{8\beta^2 cx^2}\right\}}dp$$

(*b*) When $(1+2\beta x^2)=\dfrac{e^{-\beta x^2}}{2\beta c}$

$$y=A_1\int_{-1}^{\infty}\frac{e^{-pce^{\beta x^2}}}{p-1}(p+1)^{\frac{1}{2\beta x^2}}dp$$

The other integral does not exist

(*c*) When $(1+2\beta x^2) < \dfrac{e^{-\beta x^2}}{2\beta c}$,

no convergent integral is obtained. In the integral whose limits are $-\infty$ and -1, the integrand diverges very rapidly as p approaches $-\infty$ In the second integral whose limits are -1 and ∞, $p=1$, is within the range of integration and the power of $(p-1)$ in the integrand is negative and numerically greater than unity

Case B —β is positive and c is negative $(=-a)$

(*a*) When $(1+2\beta x^2) > \frac{e^{-\beta x^2}}{2\beta a}$,

$$y=A_1\int_{-1}^{1} e^{pae^{\beta x^2}}(p-1)^{\left\{\frac{1-2\beta x^2}{4\beta x^2}+\frac{e^{-\beta x^2}}{8\beta^2 ax^2}\right\}}(p+1)^{\left\{\frac{1-2\beta x^2}{4\beta x^2}-\frac{e^{-\beta x^2}}{8\beta^2 ax^2}\right\}}dp$$

$$+B_1\int_{-\infty}^{-1} e^{pae^{\beta x^2}}(p-1)^{\left\{\frac{1-2\beta x^2}{4\beta x^2}+\frac{e^{-\beta x^2}}{8\beta^2 ax^2}\right\}}(p+1)^{\left\{\frac{1-2\beta x^2}{4\beta x^2}-\frac{e^{-\beta x^2}}{8\beta^2 ax^2}\right\}}dp$$

(*b*) when

$$(1+2\beta x^2)=\frac{e^{-\beta x^2}}{2\beta a},$$

$$y=A_1\int_{-\infty}^{1}\frac{e^{pae^{\beta x^2}}}{p+1}(p-1)^{-\frac{1}{2\beta x^2}}dp$$

The other integral does not exist

(*c*) When

$$(1+2\beta x^2) < \frac{e^{-\beta x^2}}{2\beta a},$$

both the integrals do not exist.

Cases C and D —When β is negative, primitives in both the cases are found to be divergent.

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ANNOTATED LIST OF THE HELMINTHS RECORDED FROM DOMESTICATED ANIMALS OF BURMA

PART I—TREMATODA

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Communicated by Dr H R. Mehra

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SUMMARY

An attempt has been made in this paper to furnish an up-to-date list of the helminth parasites of domesticated animals of Burma Important and controversial points in the structures and life-histories of some of these parasites have also been dealt with

Introduction

Not much is known about the worms parasitising domesticated animals in Burma The wide variety of helminths and the importance of the annual loss caused by their presence has attracted very little attention Apart from the sporadic mention of one or the other form of parasite by a few veterinary workers, until very recently the subject was totally neglected The first investigation was made by Evans and Rennie (1908, 1909), who published two papers on 'Notes on some parasites in Burma,' which embodied the accounts of the common amphistomes of cattle and elephants and two other trematodes—*Eurytrema pancreaticum* from cattle and *Fasciola jacksoni* from elephant—and in which no mention was made of the Cestoda and Nematoda. Subsequently Gaiger (1910, 1915), in his two check-lists of the parasites of domesticated animals of India, mentioned a few common forms present in Burma. No attempt at systematic study was made till 1922 when Prof Meggitt, as Professor of Biology in the University of Rangoon, with the collaboration of his staff and others, began a comprehensive survey of the helminth fauna and the problems connected with it.*

The heavy toll that parasitism takes annually from the domesticated animals in Burma in the form of loss of life is alarming, but its baneful influence on the remaining stock can hardly be ignored by the helminthologist. Thousands of such animals labour under a continuous inefficiency due to parasitism, though they may not actually die as its result. Diseased stock can hardly be expected to procreate healthy offspring and hence this original inefficiency is, in most cases, perpetuated or accentuated from generation to generation, seriously lessening the output. It should always be borne in mind that helminths are specially injurious to young stock, stunting their growth and reducing their vitality Timely diagnosis and regular treatment when combined will go a long way towards avoiding heavy financial losses. If the damage done by helminths could be expressed in money values the pressing need for their eradication would be recognised immediately as urgent for the economic welfare of mankind in general It is with a view to furnish an up-to-date list of the helminth parasites of domesticated animals of Burma and with the object of dealing with important and controversial points in the structures and life-histories of some of these parasites that the present work is undertaken The material has been chiefly obtained from the slaughter-houses of Rangoon and the near vicinity Animals have also been dissected from time to time in the laboratory of the Institute and worms collected It is much regretted that, owing to lack of material, in the present account very little on equine parasites can be reported. The animals chiefly studied have been elephant (*Elephas maximas*†), cattle (*Bos indicus*), goat (*Capra hircus*), sheep (*Ovis aries*), pig (*Sus cristatus*), dog (*Canis familiaris*), cat (*Felis catus*), fowl (*Gallus gallus*), duck (*Anas boschas domestica*) and pigeon (*Columba livia domestica*) In the present and the subsequent lists the following terms are used with reference to the occurrence of the parasites with respect to their hosts rare to mean approximately 1%, occasional 10%, frequent 25%, common 50%, and usual 80%

SYSTEMATIC

Class TREMATODA Rudolphi 1808

Order Digenea v Beneden 1858

Suborder Prosostomata Odhner 1905

Family Fasciolidae Railliet 1895.

Subfamily Fasciolinae Stiles and Hassall 1898.

Fasciola Linnaeus 1758.

Fasciola hepatica Linnaeus 1758.‡

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* Very recently when the present work was in progress Bhattacharya (1937) published two check-lists, one on Trematoda and Cestoda and the other on Nematoda.

† The names adopted for the hosts are those given in '*List of Vertebrated Animals*,' Vol. 1 Zoological Society of London, Centenary Edition

‡ Not found by author

Host Sheep, goat.

Location Liver and bile-ducts

This species is reported by various authors (Neumann 1905, Evans and Rennie 1908, Bhattacharjee 1937) from the bile-ducts of sheep and goat, but no case has been observed either by Bhalerao (1924, 140) or by workers in the university

Fasciola gigantica Cobbold 1885.

Host Cattle, buffalo

Location Liver and bile-ducts

Common Recorded by several authors from Burma

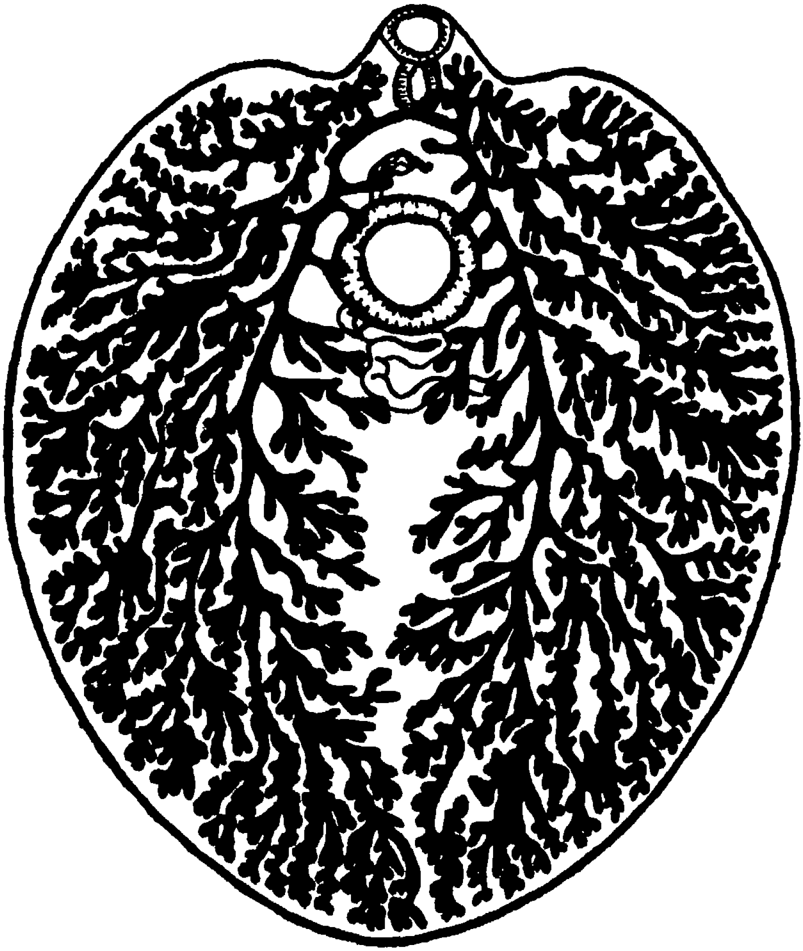

Fig 1

Fasciola jacksoni (Dorsal view)

Fasciola jacksoni Cobbold 1869

Host Elephant.

Location Liver, bile-ducts and duodenum

In previous descriptions no mention is made of the 'cephalic cone' and the 'shoulder' that are conspicuous in the present forms collected in Burma. As the usual figure given in helminthology books is that of Cobbold (1882, pl 24, fig 12) which does not show these structures, an original figure is appended Reported by various authors from Burma

Subfamily Fasciolopsinae Odhner 1910

Fasciolopsis Looss 1899

Fasciolopsis buski (Lankester 1857)

Host Pig

Location Intestine

Infection is approximately 2-3% in healthy pigs and 5—7% in emaciated ones. As it is the large intestinal fluke of man and the pig in Central and South China, Formosa, Tonkin, Assam and Bengal, the presence of these worms in Burma suggest that there is a continuous belt from Formosa to Bengal Its occurrence in man in Rangoon requires investigation Source of infection usually the water chestnut (*Trapa natans*, *T bispinosa* the latter being abundant in Burma), on the leaves and nuts of which the cercariae usually encyst Recorded previously by Bhalerao (1924, 140, 1926, 292)

Family Dicrocoeliidae Odhner 1910

Subfamily Dicrocoeliinae Looss 1899

Eurytrema Looss 1907

Eurytrema pancreaticum (Janson 1889)

Host Cattle.

Location Pancreatic and bile-ducts.

Usual, but according to Evans and Rennie only common Rosy red to brick red in colour when alive Size variable, depending on degrees of maturity and extension and contraction of body during fixation Length of mature specimens 3—16 mm., maximum breadth 0 528—8 5 mm Body thick and provided with spines, which are often lost in adults Suckers large; oral larger, equal to, or smaller than ventral Posterior end of cirrus sac slightly anterior or posterior to the anterior margin of ventral sucker

Bhalerao (1936, 163-180) maintains the specific identity of *E dajii* despite the contention of Purvis (1931, 583-584) that it is synonymous with *E pancreaticum* The three important characters on which *E dajii* is based are the possession of cuticular scales, a ventral sucker larger than the oral, and the failure of the cirrus sac to reach anterior margin of the ventral sucker Another character, of but slight importance in systematic classification but considered important by Bhalerao, is the absence of the opening of Laurer's canal in *E dajri* and its presence in *E pancreaticum* Apart from the existence of a pore it is often difficult to find the canal itself In some of the larger specimens I could see something like an opening at the end of the laurer's canal, but whether it be a true opening I hesitate to say definitely With regard to the other points of difference, that Bhalerao himself does not consider the relative size of ventral and oral suckers as valid character seems obvious from his recent statements on *E pancreaticum* from Hyderabad and Bengal respectively In the larger specimens from Hyderabad he mentions that the oral sucker was distinctly larger than the ventral, whereas in the material from Bengal the ventral sucker was larger than the oral It seems then that in *E pancreaticum* the ventral sucker may be either equal to, or smaller or larger, than the oral and therefore *E dajri* cannot be regarded as distinct by reason of its ventral sucker being larger than its oral To this attention was drawn by Evans and Rennie as early as 1908 (pp 20) wherein they mention a ventral sucker "usually larger than that of the anterior sucker, but in a number of specimens the reverse is to be seen" The extent of the cirrus sac in *Eurytrema* is also not an important character, as could be seen from the great variation in size in the specimens collected in Rangoon it varies with the amount of contraction and expansion of the body and the technique employed during fixation The presence or absence of cuticular scales or spines in *Eurytrema* also does not appear to be of any importance to the author, since in a large variety of trematodes it is known, that though they may be present in younger forms, they are shed in the fully grown specimens Their absence is also known in case of material that has been preserved for a long time, and whose identity is undoubted Therefore, the author feels that there is no justification in maintaining *E dajri* as distinct from *E pancreaticum* Reported by several authors from Burma.

Family Lepodermatidae Luhe 1901

Subfamily Prosthogoniminae Luhe 1909

Prosthogonimus Luhe 1899

Prosthogonimus Sp

Host Fowl

Location Egg

Recently a specimen has been obtained by Mr S Singh of Mandalay Agriculture College from the egg of a Rhode Island Red hen belonging to the Agricultural Farm The specimen had been kept long in saline before Singh's attention was drawn towards it and a part of it near anterior region had been damaged. The specimen definitely belongs to the genus *Prosthogonimus*, but in view of the damaged condition of the specimen it is not possible to assign it to any of the described species.

Family Echinostomidae Dietz 1909
Subfamily Echinostominae Odhner 1910
Echinostoma Rudolphi 1809
Echinostoma revolutum (Frolich 1802)

Host Duck

Location Caeca and rectum.

First record of this parasite from Burma. Eighteen out of fortyseven ducks examined were infected with this parasite, the number ranging usually from 3—8, rarely less or more, but never exceeding more than 14. Specimens from caeca are larger and hence older than those from rectum A large number of new species (definitely eleven and eight questionable) has been created which differ from the present one mainly in the arrangement of collar-spines and slight variation in the topography of the organs specially the extension of the cirrus sac with respect to ventral sucker Though the hosts in many cases are different, in all probability these new species are synonymous with the present form There is a wide range of hosts and a great variation in body dimensions. Length 10—22 mm and the cirrus sac in some cases extends slightly posterior to anterior margin of the ventral sucker

Subfamily *Himasthlinae* Odhner 1910
Paryphostomum Dietz 1909
Paryphostomum sufrartyfex (Lane 1915)

Host Pig

Location Intestine.

Common The parasite is chiefly reported from pigs of Assam and Burma but a case of human infection is also reported from Assam Whether men in Burma are susceptible to infection by this parasite is a problem of public health importance.

Bhalerao (1924, 143—146) described as *Testifrondosa cristata*, from pigs of Rangoon, some trematode parasites, which in all essential characters resemble *Paryphostomum sufrartyfex* (Lane 1915), the chief differences in the two forms being the presence of a receptaculum seminis and the absence of a 'head-collar' in the former No importance can be attached to the shape of the excretory vesicle, which he described as a pear-shaped organ instead of Y-shaped In mature and fixed specimens the two limbs of the Y appear inconspicuous, due to the profuse development of vitellaria in their vicinity, and unless very carefully examined the excretory bladder appears pear-shaped. The mention of a receptaculum seminis in the description of *T cristata* and its absence from the figure is an enigma The only important difference left is the absence of a 'head-collar' in *T cristata*, an oversight probably due to the limited number of parasites available to Bhalerao and the retracted nature of the collar in most of the specimens he studied, it is difficult to see the collar when it is retracted and the anterior end of the body is curved ventrally, and also to distinguish between it and the body spines, both of which are so well developed. In this connection Bhalerao (1931, 476) in his description of *Paryphostomum sufrartyfex*, referring to certain specimens states 'that it was difficult to make out any spines on the collar' and this was probably what had happened with the majority of the specimens of *T. cristata* he examined. The writer has found many specimens where the anterior tip of the body curves ventrally so that the pharynx comes to lie at the anterior extremity and the oral sucker occupies the position of the pharynx, where some of the collar spines are lost and others towards the body margin look like the well-developed body spines and where the collar, which normally looks so conspicuous from the ventral surface, is obliterated due to the apposition of the dorsal surface of the anterior extremity of the body to the ventral. Many times specimens have been obtained from pigs of Rangoon and in all cases careful examination showed what apparently looked like *T. cristata*, was in reality *P. sufrartyfex*, commonly present in the pigs of Bengal and Assam. A single specimen, very much distorted, left by Bhalerao in the Helminthological Collection of the Rangoon University and some of the prepared slides which formed the basis of Bhalerao's description, left in the collection of Dr. G. E. Gates, revealed, on careful examination, the presence of collar and collar-spines. There is thus no doubt but that *Testifrondosa cristata* of Bhalerao is synonymous with *Paryphostomum sufrartyfex* (Lane 1915).

Family Notocotylidae Lühe 1909

Catatropis Odhner 1905

Catatropis verrucosa (Frolich 1789)

Host: Duck.

Location: Caeca.

First record of this parasite from Burma. Nine out of fortyseven ducks examined were infected with this parasite, the number in each case obtained being usually 2—4 but rarely 1 or as many as 12. The details of the life-history of this species is still very imperfectly known and it is doubtful whether *Cercaria imbricata* Looss 1893 is the larval form of this trematode. Szidat (1930) has studied the different larval stages passed through the bodies of the snail *Planorbis (Coretus) corneus*. The miracidium develops into a sporocyst which gives rise to rediae. The cercariae have three eye-spots and on leaving the snail usually encyst on water plants or snails, etc., which when ingested by the final host develop into mature worms within a short time after infection.

Family Schistosomidae Looss 1899.

Subfamily Schistosominae Stiles and Hassall 1898.

Schistosoma Weinland 1858

Schistosoma bovis (Sonsino 1876)

Host Cattle.

Location Mesenteric vein

Faust (1921) regards *Cercaria ocladena*, a pharyngeal brevifurcate distome cercaria, as the larva of *S. bovis* whereas all other larvae of this family are apharyngeal Recorded previously by Bhattacharjee (1937).

Family Paramphistomidae Fischoeder 1901

Subfamily Paramphistominae Fischoeder 1901

Paramphistomum Fischoeder 1901

The species of this genus require revision The descriptions of *Paramphistomum microon* Railliet 1924 and *P birmiense* Railliet 1924 are too inadequate for recognition while the opening of Laurer's canal as a specific distinction, though valid theoretically, leaves much to be desired from the practical standpoint of identification

Paramphistomum birmiense Railliet 1924*

Host Cattle

Location Bile-ducts

Recorded by Evans and Rennie (1908 Amphistome No 3) and Railliet (1924)

Paramphistomum cervi (Zeder 1790)

Host Cattle, goat.

Location Rumen, bile-ducts.

Usual Rao and Ayyar (1932, 402—405) claim to have found cercariae of *P cervi* from *Indoplanorbis exustus* which are identical with *Cercariae indicae* xxvi Sewell 1922 These cercariae when fed to a calf developed to *P cervi*, but the writer's careful examination of the forms obtained after experimental feeding of the encysted cercariae of *Cercariae indicae* xxvi Sewell 1922 to goats showed that what apparently looked like a *Paramphistomum* was in reality a *Cotylophoron* (See discussion under *Cotylophoron cotylophorum*) Recorded previously by Evans and Rennie (1908), Bhalerao (1924) and Bhattacharjee 1930, 1937)

Paramphistomum explanatum (Creplin 1849).

Host Cattle, buffalo.

Location Stomach

First record of this parasite from Burma.

Paramphistomum microon Railliet 1924*

Host Cattle, buffalo
Location Caecum
Recorded by Evans and Rennie (1908 Amphistome No 2) and Railliet (1924)

Paramphistomum orthocoelium Fischoeder 1901 *

Host Cattle
Location Rumen
Recorded by Gaiger (1910, 1915)

Cotylophoron Stiles and Goldberger 1910

Cotylophoron cotylophorum (Fischoeder 1901)

Host Cattle, buffalo, goat, sheep
Location Rumen

Common Opinions seem to differ as to the advisibility of considering *C indicum* Stiles and Goldberger (1910) a distinct species from *C cotylophorum* Maplestone (1923, 151), Fukui (1929, 319), Travassos (1934, 37) and Neveu-Lemaire (1937, 138) consider *C indicum* as a synonym of *C cotylophorum* whereas Stunkard (1925, 138), and Bennett (1936, 93) are inclined to consider *C indicum* as a distinct species Unless further evidence be produced it is the view of the writer that *C indicum* is a synonym of *C cotylophorum.*

In India and Burma chief intermediate host is *Indoplanorbis exustus* The cercaria can easily be distinguished from that of *P cervi* by its smaller size, shorter tail and particularly by the presence of evaginations —— one median near the middle of the body and a lateral pair immediately posterior to the eyes —— arising from the excretory vessels The cercariae encyst on vegetation and the metacercaria lives over three months On being swallowed by the final host the encysted cercariae are liberated in the intestine from where they afterwards migrate forward to rumen and reticulum where they grow into adults. Bennett (1936, 77—78) considers all the amphistome cercariae described by Sewell in the 'Pigmentata' group different from those of *C cotylophorum* and he claims that this is the first description of the larval form The present writer (1931, 177—179) conducted experiments on goats with cysts of *Cercariae indicae* xxvi Sewell 1922 encysted on leaves. Unfortunately the hosts died before the worms could mature and the young amphistomes so obtained resembled *Paramphistomum* in general appearance Study of stained specimens and serial sections of these young worms revealed, even at this early stage of development, the presence of a genital sucker — a character that chiefly differentiates a *Cotylophoron* from a *Paramphistomum* Whether these young worms are to develop into *Cotylophoron cotylophorum* or some other species of the genus I hesitate to say, but knowing that there is only one species of *Cotylophoron* reported from cattle and goats of India and Burma and that too in all probability *Cotylophoron* *cotylophorum* the author feels convinced that *Cercariae indicae* xxvi Sewell 1922 is a larval form of *Cotylophoron cotylophorum* and the minor differences pointed out by Bennett (1936, 77-78) such as the differences in size of suckers and oesophagus and the degree of development of genitalia are all variations found in the successive stages of development. Recorded previously by Bhattacharjee (1937)

Subfamily Gastrothylaxinae Stiles and Goldberger 1910

Gastrothylax Poirier 1883.

Gastrothylax crumenifer (Creplin 1847)

Host Cattle, buffalo, goat.

Location Rumen

Deep claret when fresh. Length 9—18 mm, breadth 4—5 mm Recorded previously by Gaiger (1915), Bhalerao (1926) and Bhattacharjee (1937)

Fischoederius Stiles and Goldberger 1910

Fischoederius elongatus (Poirier 1883)

Host Cattle

Location Rumen

Deep claret when fresh Length showing extreme variation, 6—20 mm., breadth smaller than *Gastrothylax crumenifer*, 2-3 mm Rao and Ayyar (1932, 405) consider *Cercariae indicae* xxix Sewell 1922, which are usually obtained from the snails *Limnaea acuminata*, *L. succinea* and *Gyraulus euphraticus* to be the larval form of this parasite Recorded previously by Bhattacharjee (1937)

Subfamily Cladorchinae Fischoeder 1901

Pseudodiscus Sonsino 1895

Pseudodiscus collinsi (Cobbold 1875)

Host Elephant

Location Large intestine

Though this parasite is mainly reported from Equidae, in Burma it has only been recorded from the elephant. Recorded previously by Bhalerao (1935) and Bhattacharjee (1937)

Hawkesius Stiles and Goldberger 1910

Hawkesius hawkesi (Cobbold 1875)

Host Elephant.

Location Colon

Recorded previously by several authors from Burma.

Pfenderius Stiles and Goldberger 1910
Pfenderius papillatus (Cobbold 1882)

Host Elephant
Location Colon

Recorded previously by Bhalerao (1926) and Bhattacharjee (1937)

Family Gastrodiscidae Stiles and Goldberger 1910

Gastrodiscus Leuckart 1877
Gastrodiscus secundus Looss 1907

Host Horse
Location Large intestine

Recorded by several authors from Burma.

Gastrodiscoides Leiper 1913
Gastrodiscoides hominis (Lewis and McConnell 1876)

Host Pig
Location Intestine

First record of this parasite from Burma Infection is approximately 2-3% The parasite is also reported from caecum of man specially from Assam where it causes inflammation of the mucosa with attendant symptoms of diarrhoea No human case is yet reported from Burma but their presence in pigs appears to be of public health importance

Homalogaster Poirier 1883
Homalogaster paloniae Poirier 1883

Host Cattle
Location Large intestine

Reported by Evans and Rennie (1908, 13—15), 1 case in 280, from cattle brought from Mandalay to Maymyo The writer obtained more than 1000 from a single ox from Kamayut.

I take the present opportunity of expressing my thanks to Mr R. Clarke Glover, M R.C V S for the gift of specimens which have materially assisted in the preparation of this paper and to Prof Meggitt for the invaluable help and assistance he unfailingly extends to me in my work My thanks are also due to Dr G E. Gates for the loan of specimens of *Paryphostomum sufrartyfex* (Lane 1915), which formed the basis of Bhalerao's description of *Testifrondosa cristata*

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COMPOSITION OF PATENT STILL MOLASSES FUSEL OIL OF INDIAN ORIGIN, PART I

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SUMMARY

Indian molasses fusel oil obtained from the Patent Still Distillery at Rosa, Shahjahanpur through the courtesy of Messrs Carew & Co., was exhaustively examined and fractionally distilled hundreds of times, whereby it was resolved into the following constituents —

Ethyl alcohol, Isopropyl alcohol, n propyl alcohol, isobutyl alcohol n butyl alcohol, secondary butyl alcohol, isoamyl alcohol, hexyl alcohol (normal), octyl alcohol (normal), furfural, acetal, ethyl isobutyrate, water and a solid crystalline hydrocarbon $C_{30}H_{60}$, M P 62 C

There are also some basic constituents in the oil present in very minute quantities which could not be isolated in sufficient quantities for separation into constituents But never the less they were found from qualitative examination to belong to the pyridine group of heterocyclic compounds The crystalline hydrocarbon which had a characteristic odour having a distant resemblance to petitgrain oil has a single double bond in the molecule as found from the iodine value The compound appears to be identical with *Melene* described in literature and which was previously obtained only from synthetic sources Its existence in molasses fusel oil is very interesting

Fusel oil obtained as a high-boiling residue in the distillation of spirit from various fermented liquors, *e g.*, grape juice, potato mash, malt wort, diluted cane and beet molasses have been investigated by a large number of workers, such as Le Bel,[3] Rabuteau,[4] Ordonneau,[2] Windish,[5] Dupre,[1] and others and amongst the substances obtained from the fusel oil are ethyl alcohol, n-propyl alcohol, n-butyl alcohol, isobutyl alcohol, tertiary butyl alcohol, n-amyl alcohol, isoamyl alcohol, n-hexyl alcohol, n-heptyl-alcohol, furfural, esters of aliphatic acids, pyridine bases and water Isopropyl alcohol was reported in potato fusel oil by Rabuteau, but was not confirmed by later workers The principal alcohols obtained from cane molasses fusel oil are the isoamyl alcohol, butyl and isobutyl alcohols, and n-propyl alcohol Iso-propyl alcohol, obtained in large proportions from this substance in the present investigation, therefore constitutes a marked departure from the results of previous workers Other substances that are also being reported for the first time in cane molasses fusel oil are primary octyl alcohol, acetal, ethyl isobutyrate and a hydrocarbon, "melene" with a molecular formula $C_{30}H_{60}$ The occurrence of this hydrocarbon is exceedingly interesting This substance has perhaps been formed from the waxes in the cane which were transmitted to the molasses and from there to the fusel oil after reduction during the fermentative process. Its presence in the fusel oil is accounted for due to its volatility in the vapours of the higher alcohols and also in steam under increased pressure

Molasses fusel oil also contains small quantities of organic acids and amongst them only acetic, butyric and oenanthic acids could be detected qualitatively due to the minute proportion present. Most of the alcohol fractions that have been isolated also contain aldehydes in very small proportions not exceeding 20 parts in 100,000 They have also esters in traces mixed with them, the ester value varying between 60 to 90 per 100,000 Furfural has been isolated in a pure state from molasses fusel oil which was not done by any previous worker N-octyl alcohol has been found to be present in molasses fusel oil in comparatively large proportions and has got a floral smell in high dilutions

EXPERIMENTAL

Molasses fusel oil, as obtained from the patent still of Messrs Carew & Co at Rosa (Shajehanpur), was a light cream-coloured and slightly opalescent liquid possessing a peculiar characteristic odour The liquid had a specific gravity of 0 9982 at 25°C, and was weekly acidic in reaction The substance was fractionally distilled in one litre lots with the help of two fractionating columns, one of Glinsky's pattern, 16 inches long and provided with five bulbs and four glass ball traps and the other of Young's pattern, 21 inches long and filled with bits of glass tubes one centimeter long and three millimeter in external diameter A double surface glass condenser 18 inches long was used along with the distilling apparatus for the condensation of the various fractions The following table will indicate the results obtained

Table I

Batch I Total quantity taken = one litre

Fraction No	Boiling range	Quantity of distillate
1	75-80°C	12 c c.
2	80-90°C	100 c c.
3	90-95°C	202 c.c
4	95-100°C	34 c c.
5	100-105 C	16 c c
6	105-110°C	16 c c.
7	110-120°C	24 c c.
8	120-125°C	204 c c.
9	125-130°C	328 c c
10 Residue boiling above 130°C		60 c c
11 Experimental loss		4 c c
	Total	1000 c c

Fraction Nos 1, 2, 3, and 4 were united together, when the mixture separated into two layers, A and B They were separated and fractionated again

Table II

A Total quantity = 248 c c

Fraction No	Boiling range	Quantity
1	75-79°C	4 c c
2	80-84°C	9 c c
3	85-89 C	210 c c
4	90-94°C	12 c c
5	95 100 C	11 c c
6	Loss	2 c c
	Total	248 c c

Table III

B Total quantity = 100 c c

Fraction No	Boiling range	Quantity
1	80-84°C	11 c c
2	85-89 C	2 c c
3	90-94°C	2 c.c
4	95-100°C	76 c c.
5	101-104°C	nil
6	105-109°C	1 c c
7	110-119°C	1 c c
8	120-125°C	2 c c
9	126-131°C	4 c c
10	Loss	1 c c
	Total	100 c c.

A second lot of 1000 c c was similarly distilled and also a third lot of the same quantity The various fractions boiling at definite ranges were united together and refractionated after dehydration where necessary, with the result given in table IV Altogether 52 fractionations were done for Batch No 1, although only 14 are recorded here

Table IV

Total quantity taken = 1000 c c

Fraction No	Boiling range	Quantity	Constituent
1	75-79°C	3 c c	ethyl alcohol
2	80-82°C	4 c c	ethyl alcohol-isopropyl alcohol mixture
3	83-87°C	232 c.c.	isopropyl alcohol
4	90-95°C	5 c c	isopropyl-n-propyl alcohol mixture.

Fraction No	Boiling range	Quantity	Constituent
5	96-98°C	31 c c.	n-propyl alcohol
6	99-100°C	58 c.c	water
7	101-105°C	8 c.c	acetal
8	106-109°C	14 c c.	isobutyl alcohol
9	110-112°C	8 c.c.	ethyl isobutyrate
10	116-119°C	29 c c	n-butyl alcohol
11	120-127°C	8 c c.	n-butyl-isoamyl-alcohol mixture
12	128-131°C	568 c c	isoamyl alcohol
13	Ultimate residue not boiling at 150°C	22 c c.	
14	Loss	10 c.c	
	Total	1000 c.c	

The ultimate residue on allowing to stand, deposited a crystalline mass (1 5 gm) which on recrystallisation from boiling alcohol was obtained in the form of snow-white prismatic needles melting at 62°C Elementary analysis pointed it out to be a hydrocarbon and determination of the unsaturation indicated the presence of one double bond in the molecule The substance had most of the properties of solid paraffin and burnt with a luminous flame emanating the odour of burning candle Reference to literature indicated its identity with the hydrocarbon 'melene' (Found C, 85 42, H, 14 48, M W, by Rast's camphor method, 418 $C_{30}H_{60}$ requires C, 85 71, H, 14 29, M W, 420)

The mother liquor from the above crystalline mass was fractionated with a short column and separated into the following fractions —

Table V

Total quantity—18 c c

Fraction No	Boiling range	Quantity of distillate	Composition
1	155-158 C	4 c c	n-Hexyl alcohol
2	160-163°C	2 c c	Furfural
3	172-175°C	3 c c	n-Heptyl alcohol
4	197-200°C	8 5 c c	n-Octyl alcohol
5	Loss	0 5 c c	
	Total	. 18 c c	

Most of the alcohols were identified by formation of the p-nitrobenzoic ester with p-nitro-benzoyl chloride or dinitro-benzoic ester with 3 5-dinitro-benzoic acid. In many cases they were identified by formation of the corresponding acid by oxidation with potassium permanganate and preparation of the silver salt, amide or the anilide of the corresponding acid

Two more batches of fusel oils were fractionated in the same way as given in the foregoing experiments for batch No 1, and all the three sets of final results of fractional distillation of patent still molasses fusel oil are given in the following table (No VI)

Table VI

Name of constituent	Boiling range °C	Correct B P °C	M P of derivative °C	Batch I (%)	Batch II (%)	Batch III (%)
Ethyl alcohol	77-79	78	†56	1.2	1.3	1.2
Isopropyl alcohol	83-86	84	*62	23.8	15.8	17.6
n-Propyl alcohol	96-98	97	*73	3.8	2.3	3.2
Water	99-100	100		6.2	5.9	5.7
Acetal	103-105	104		0.6	1.8	1.6
Isobutyl alcohol	106-108	108	*83	1.8	1.9	1.8
Ethyl-isobutyrate	109-111	110		0.7	0.8	0.7
n-Butyl alcohol	115-118	116	*64	3.2	5.4	5.0
Isoamyl alcohol	128-131	129	Succinate (B P 297)	57.4	61.7	60.9
n-Hexyl alcohol	155-158	157	*97	0.3	0.2	0.2
Furfural	160-162	161	Phenylhydrazone (M P 95)	0.2	0.2	0.1
n-Heptyl alcohol	173-175	174		0.3	0.3	0.2
n-Octyl alcohol	197-200	199	*123	0.8	1.1	0.7
Melene	M.P 62	M P 62		0.05	0.08	0.04

The author takes this opportunity of expressing his best thanks to Messrs Carew & Co of Rosa (Shahjehanpur) for sending him several consignments of fusel oil.

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4 Rabuteau (1887) *Compt Rend*, 500

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* 3 5-dinitrobenzoate.

† p-nitrobenzoate.

ON TWO NEW TREMATODES FROM INDIAN CYPRINOID FISHES WITH REMARKS ON THE GENUS *ALLOCREADIUM* LOOSS

By B P Pande

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Communicated By Dr H R. Mehra

Received October 11, 1938

SUMMARY

The author has described in this paper two new species of the genus *Allocreadium* Looss — *A schizothoracis* and *A mahaseri*

To the three species of the genus *Allocreadium* Looss (1900), viz, *A handiai* Pande (1937), *A nicolli* Pande (1938), and *A kosia* Pande (1938), described by him from some of fresh-water fishes, the author adds in the present paper two more

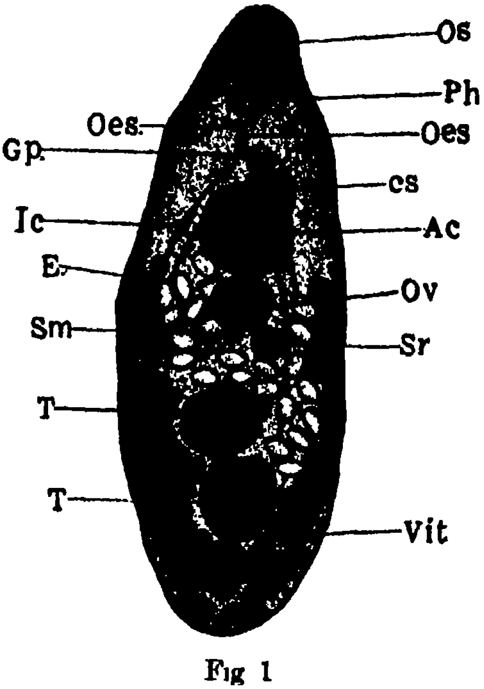

Fig 1

Allocreadium schizothoracis n sp. × 47

Ac, acetabulum, *Cs*, cirrus sac, *E*, egg, *Gp*, genital pore, *Ic*, intestinal caecum, *Oes*, oesophagus, *Os*, oral sucker, *Ov*, ovary, *Ph*, pharynx, *Sm*, shell gland mass, *Sr*, seminal receptacle, *T*, testis, *Vit*, vitellaria, species, *A schizothoracis* n sp and *A mahaseri* n sp A brief historical review of this genus has been given in one of the previously published papers.

Host *Schizothorax micropogon* Heck
Habitat Small Intestine
Locality Srinagar (Kashmir)

Description —These specimens were obtained by Dr H R. Mehra at Srinagar, to whom my best thanks are due for giving me this material to study and describe. Body oval or slightly elongated, small, with narrow anterior and broad posterior ends, 1 6-1 7* in length and 0 57-0 64 in breadth which is uniform behind acetabulum Oral sucker subterminal, nearly rounded, 0 18 × 0 19 in size, prepharynx not observed, pharynx 0 08-0 09 in diameter, œsophagus 0 1-0 14 in length, intestinal bifurcation at one-fourth of body-length from anterior extremity and close in front of the acetabulum, intestinal caeca terminate a short distance in front of the posterior end Acetabulum spherical, slightly larger than oral sucker, 0 2 in diameter Excretory pore terminal. Genital pore median, close in front of intestinal bifurcation Testes nearly spherical, equal in size, 0 18-0 2 in diameter, tandem or anterior testis may be slightly lateral in position, contiguous, in posterior half of body near its middle, cirrus-sac with coiled vesicula seminalis in its basal half and a small pars prostatica and a short ductus ejaculatorius surrounded by a few prostate gland cells in the anterior portion, extending from the genital pore in a curve around the acetabulum to some distance beyond its anterior border but never reaching to its centre posteriorly Ovary median, just behind the acetabulum, near the middle of the body-length, somewhat spherical, 0 14 × 0 15 in size, small rounded receptaculum seminis posterolateral to ovary, shell-gland mass lateral to hinder half of ovary, slightly anterior to receptaculum seminis on the other side of the median line, uterus mainly between anterior testis and acetabulum with a coil passing posteriorly beyond the anterior testis to anterior border of posterior testis, containing as many as twenty-five eggs, ripe eggs 0 077 in length and 0 059 in breadth, vitelline follicles extend from the level of posterior end of acetabulum to posterior end of body, uniting behind the posterior testis

Remarks —The size of the body, sucker ratio, more posterior extent of the uterus in relation to the testes, comparatively larger size of the eggs in proportion to the body size and anterior extent of the vitellaria distinguish the new species from the three other *Allocreadium* species described by the author from some of the fresh-water fishes. Among the species of *Allocreadium* known from other countries in which the vitellaria do not extend anterior to the acetabulum, *A schizothoracis* n sp in the acetabulum being larger than the oral sucker resembles *A transversale* (Rud) after Lühe, *A. pallens* (Rud) after Wallin, *A hasu* Ozaki (after Yamaguti),

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*All measurements are in mm

A japonicum Ozaki (after Yamaguti), and *A beleosomi* Simer *A transversale* is distinguished from the new species on account of the larger body size, different sucker ratio, anterior extent of the vitellaria (in *transversale* follicles not reaching to the posterior level of acetabulum), and greater size of eggs. *A pallens* differs from the new species in the greater body size, acetabulum being twice as large as the oral sucker, and ovary situated next to the testes. *A hasu* is distinguished from it by the larger size of its body, different sucker ratio, irregularly lobed testes, slightly lateral genital pore, and uterine coils lying between anterior testis and acetabulum *A japonicum* can likewise be separated from it by the sucker ratio *A. belcosomi*, which is a slightly smaller species, is easily separated off from the new species on account of the different sucker ratio, more anterior position of its acetabulum, cirrus-sac extending posteriorly beyond centre of the acetabulum, ovary immediately pre-testicular, uterus between the ovary and the acetabulum, and smaller size of its eggs

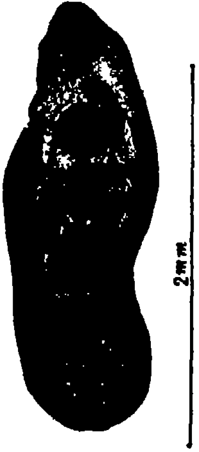

Fig 2

A mahaseri n sp.

Host *Barbus tor* Ham
Habitat Small Intestine
Locality Almora, Kumaon Hills

Description —Body elongated, somewhat flattened dorsoventrally, with anterior tapering and posterior broadly rounded ends, 2·23* in length and 0·8 in maximum breadth in ovarian zone Oral sucker subterminal, slightly longer than broad, 0·26 × 0·25 in size, prepharynx not observed, pharynx broader than long, 0·12 × 0·13 in size, œsophagus 0·14 in length, dividing close in front of the acetabulum, intestinal caeca terminate near posterior end Acetabulum spherical, nearly equal in size to the oral sucker, 0·26 in diameter, situated slightly in front of one-third of body-length from anterior extremity. Excretory pore terminal. Genital pore anterior to intestinal bifurcation, half-way between posterior border of pharynx and anterior border of acetabulum. Testes in posterior half of body, nearly equal in size, somewhat spherical in shape, 0.32 × 0.31 in dimensions; cirrus-sac elongated, anterolateral to acetabulum with its greater part lying ventral to right intestinal caecum in the region of the acetabulum but in front of acetabulum cirrus-sac overarches intestinal bifurcation to open at the genital pore; vesicula seminalis coiled in proximal half of cirrus-sac; well-developed prostate gland cells surrounding pars prostatica and ductus ejaculatorius. Ovary median, post-acetabular, slightly in front of middle of body-length, broader than long, 0.18 × 0.2 in size; transversely placed receptaculum seminis lateral in position; well-developed yolk-reservoir and shell-gland cells close behind the ovary, median and at the middle of body length; uterus between anterior testis and acetabulum, containing 30—35 eggs; ripe eggs 0.08 in length and 0.056 in breadth; vitelline follicles extending from near the anterior level of acetabulum to the extreme posterior end of the body, uniting posteriorly behind posterior testis.

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*All measurements are in mm

Remarks.—This species, in the nearly equal size of its suckers, resembles the species, *A. isoporum* and *A. lobatum*, but it is distinguished from them by the anterior extent of vitellaria. *A. mahaseri* n.sp. is separated from *A. nicolli*, with which it agrees in the anterior extent of the vitellaria, on account of the smaller size of its body, nearly equal suckers, more forward position of the genital pore in relation to the intestinal bifurcation, testes being in tandem and contiguous, absence of uterine coil extending posteriorly beyond anterior border of anterior testis, and larger size of its eggs. *A. kosia* is a much larger species than *A. mahaseri* and differs from it on account of the sucker ratio, position of the genital pore just below intestinal bifurcation, posterior testis longer than the anterior one, extent of the cirrus-sac, more anterior position of the acetabulum, ovary and laterally situated shell gland mass, more posterior extent of the uterine coils in relation to the anterior testis, vitelline follicles extending up to the middle of the acetabulum, and smaller length of its eggs. From *A. handiai* it is distinguished, among other characters, by the smaller size of its body, nearly equal suckers, more anterior extent of the vitellaria, median position of the ovary, extent and position of the cirrus-sac, and smaller size of its eggs. *A. schizothoracis* n.sp. differs from *A. mahaseri* n.sp. on account of the smaller size of the body, acetabulum larger than the oral sucker, more posterior extent of the uterus, and vitelline follicles extending anteriorly only to the hinder border of the acetabulum.

Remarks on the genus *Allocreadium*

From a study of these five species and others known in this genus the author considers that the characters of these forms which show marked differences are the position of the genital pore, length of the œsophagus, posterior extent of the cirrus-sac, anterior extent of the vitelline follicles, and posterior extent of the uterus In some of these species one or more of these characters are so distinct that systematists might be led into creating higher systematic units for them But such a separation is likely to lead to confusion and is not possible in view of the fact that these characters are not really so clear-cut and tend to intergrade This becomes evident when a larger number of species is taken into account and the differences shown by them in the above-mentioned characters compared together Thus, the genital pore is situated near the intestinal bifurcation in a large number of species varying in position, in front of it as in *mahaseri*, below it as in *kosia*, and immediately posterior to it as in *pseudotritoni*, while in *ictaluri* and *handiai* it lies much behind the intestinal bifurcation, œsophagus bifurcates close in front of the acetabulum in *schizothoracis*, *mahaseri*, or much in front of it as in *ictaluri* and *handiai*, the cirrus-sac may extend posteriorly to the anterior border of acetabulum as in *handiai*, slightly beyond it as in *schizothoracis*, or may extend further backward as to lie slightly beyond its hinder margin as in *kosia*, vitelline follicles may commence behind the acetabulum as in *handiai* and *isoporum*, from the posterior end of the acetabulum as in *schizothoracis*, from the middle of the acetabulum as in *kosia*, from the anterior end of the acetabulum as in *mahaseri*, from the posterior margin of oral sucker as in *pseudotritoni*, uterine coils in most of the species lie between anterior testis and acetabulum, e g, *lobatum*, *handiai*, *mahaseri*, *pseudotritoni*, etc while they have been seen to extend backwards as far as middle of anterior testis in *nicolli* and *kosia* and to anterior border of posterior testis in *schizothoracis* It may be noted that if the character of the distribution of the vitelline follicles is taken into account in *pseudotritoni* and *ictaluri*—species resembling in the anterior extent of the vitellaria in front of the acetabulum, the difference in the position of their genital pores—much behind the intestinal bifurcation in the latter will be found to be present in *handiai* —a species with vitelline follicles commencing behind acetabulum It will thus be evident that the species of *Allocreadium* cannot be separated into generic or subgeneric groups A revision of the generic diagnosis has, therefore, become necessary to accommodate the species that have been added since the setting up of the genus

Diagnosis —Small to medium-sized Allocreadinæ, oral sucker larger or smaller than acetabulum, or equal in size, prepharynx present or absent, pharynx well-developed, œsophagus when present, short or long, intestinal bifurcation close in front of the acetabulum, or much in front of it, intestinal caeca reaching to near posterior end of body, excretory pore terminal or subterminal, sac-shaped excretory bladder variable in length, genital pore ventral, median or slightly lateral, between pharynx and ventral sucker, testes lobed or entire, postovarian, tandem or slightly oblique in position, in posterior half of body, cirrus-sac with coiled vesicula seminalis, pars prostatica, ductus ejaculatorius, and prostate gland cells, reaching posteriorly to anterior border, or centre, or near hinder end of acetabulum, ovary nearly rounded, dorsal, between anterior testis and acetabulum, receptaculum seminis well-developed, in level with or posterior to ovary, Laurer's canal and shell gland mass present, uterus with few to many eggs, usually coiled between anterior testis and acetabulum, sometimes extending posteriorly as far as anterior border of posterior testis and lateral to it, matraterm may be present, eggs 0 04-0 125 by 0 016-0 1 in size, vitellaria mostly lateral, overlapping caeca, united in post-testicular space, commencing from posterior margin of oral sucker or from intestinal bifurcation or acetabulum or behind acetabulum from the ovarian zone, parasites of fishes and salamander, type-species, *A isoporum* (Looss, 1894)

The author is greatly indebted to Dr H R Mehra for his many valuable suggestions and helpful criticisms

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A NEW STRIGEID TREMATODE OF THE GENUS *CRASSIPHIALA* V HAITSMA, 1925 (FAMILY DIPLOSTOMIDÆ POIRIER) FROM AN INDIAN KING-FISHER

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Communicated by Dr H R Mehra

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SUMMARY

A new strigeid trematode of the genus *Crassiphiala* V Haitsma, 1925 (family Diplostomidæ Poirier) from an Indian King fisher has been described and its relationships have been discussed

The members of the genus *Crassiphiala* are parasitic in King-fishers Van Haitsma (1925) erected this genus to include *C bulboglossa* from the belted King-fisher, *Ceryle alcyon* Hunter (1933) found, during feeding experiments with belted King-fishers, *Streptoceryle alcyon*, that the strigeid metacercaria, *Neascus ambloplitis*, Hughes, encountered in the small blackbass, develops into a species of *Crassiphiala*, *C ambloplitis* and also gave an account of the morphology of the adult of the second species of *Crassiphiala* These strigeid trematodes were placed in the subfamily Polycotylinæ of the family Strigeidæ In regard to the presence of a well-developed acetabulum in *ambloplitis*, reported to be of a rudimentary nature in the generic diagnosis, a reference to the amendment of the diagnosis for inclusion of species with acetabulum was made by Hunter Dubois (1933) removed the subfamily Polycotylinæ from the Strigeidæ to the family Alaridæ In 1934 the genus *Crassiphiala* was revised by Dubois who also gave a detailed description of *C denticulata* (Rudolphi) from *Alcedo ispida* Harwood (1936) reporting *C ambloplitis* from the intestine of *Megaceryle alcyon*, has given a key for the separation of the species included in *Crassiphiala* which includes, besides the three species enumerated above, *C gracilis* (Yamaguti) and *C cochleariformis*, (Yamaguti) The genus *Crassiphiala*, following Dubois (1936), is assigned to the sub-subfamily Crassiphialini of Dubois under Diplostomidæ

During the examination of King-fishers at Allahabad, an apparently new species of the genus *Crassiphiala* was found in the small intestine of *Halcyon smyrnensis fusca*, the white-breasted King-fisher, and is described below

Family Diplostomidæ Poirier
Subfamily Diplostominæ Monticelli
Sub-subfamily Crassiphialini Dubois.
Genus *Crassiphiala* Van Haitsma

Crassiphiala stunkardi n sp

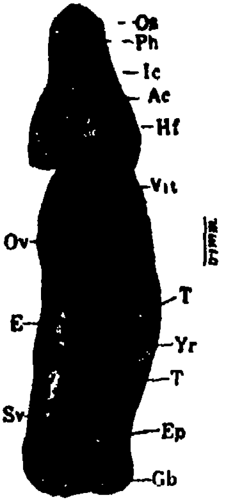

Fig 1

Crassiphiala stunkardi n sp, laterally flattened specimen

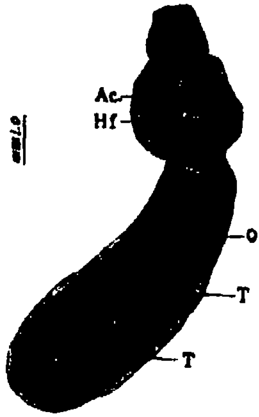

Fig 2

C stunkardi, dorsally flattened specimen

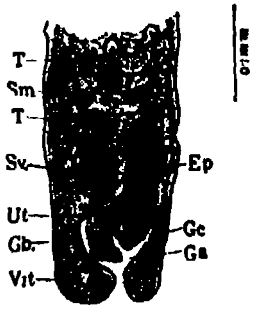

Fig 3

Sagittal section of *C stunkardi* through testicular and post-testicular regions showing the ejaculatory pouch, vesicula seminalis, genital cone, and the genital bulb in the atrium

Ac, acetabulum, *E*, egg, *Ep.*, ejaculatory pouch, *Ga*, genital atrium, *Gb*, genital bulb, *Gc*, genital cone, *Hf*, hold-fast organ, *Ic.*, intestinal cæcum, *Os*, oral sucker, *Ov.*, ovary, *Ph*, pharynx, *Sm*, shell gland mass, *Sv*, seminal vesicle, *T*, testis, *Ut*, uterus, *Vit* vitelline follicles, *Yr.*, yolk reservoir

Description—Body divided into somewhat transparent, flattened, and spoon-shaped fore-body with its margins incurved ventrally and meeting behind the hold-fast organ, and a cylindrical, more or less opaque hind-body Fore-body 0·29*—0·34 in length and 0 2 in greatest breadth in the region of the hold-fast organ, hind-body nearly twice as long as the fore-body, 0 6—0·7 in length, and 0 23 in greatest breadth in the region of the posterior testis Oral sucker ventro-terminal, 0 06—0 066 in size, pharynx slightly less than half the size of the oral sucker, 0 028 in diameter, œsophagus 0 055 in length, intestinal bifurcation in front of the acetabulum, intestinal cæca terminating near the hinder border of the seminal vesicle Acetabulum smaller than the oral sucker, 0 038—0 04 in diameter, situated close in front of the hold-fast organ Hold-fast organ well-developed, circular, penetrated by a cavity, and 0 07—0 09×0 07—0 1 in size. Adhesive-gland not recognisable Genital pore at the posterior extremity, dorsal in position, leading into the genital atrium of nearly 0 1 length and containing a well-developed genital bulb arising from its antero-ventral aspect All the genital glands including the vitellaria and uterine coils confined to the hind-body. Testes large, somewhat bean-shaped, tandem, dorsal in position, anterior testis 0 12 in length and 0 15 in breadth, a tittle in front of the middle of the body-length, posterior testis 0 1 in length and 0 16 in breadth, close behind the anterior testis, vesicula seminalis voluminous, of 0 07 length and 0 06 in breadth, immediately behind the posterior testis, lateral in position, nearer the ventral body wall, and distally curving to open into the muscular ejaculatory pouch which is of about 0 09 length and 0 045 in breadth and situated close behind the posterior testis immediately below the dorsal body wall, ejaculatory pouch, distally passing through the genital cone, opens at its apex with the terminal portion of the uterus, genital cone dorsal in position to the genital bulb Ovary transversely elongated, with entire margins, close in front of the anterior testis, median, 0 05 in length and 0 07 in breadth, shell-gland mass and well-developed yolk-reservoir inter-testicular, receptaculum seminis absent, initial coils of uterus serving as receptaculum seminis uterinum, uterus after origin from shell-gland mass running forward on the ventral side near the hinder border of the ovary wherefrom, after bending on itself, continues its backward course as a more or less straight descending limb with the distal end opening along with the terminal part of the ejaculatory pouch at the apex of the genital cone, ripe eggs 0 084 in length and 0 049 in breadth, vitellaria occupying almost all the available space of the hind-body, extending from the junction of the fore- and hind-body to the posterior extremity of the worm

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* All measurements are in mm

Remarks —*Crassiphiala stunkardi* n sp in having an acetabulum resembles the species, *C denticulata*, *C ambloplitis*, *C gracilis* and *C cochleariformis* From *denticulata* it differs in the relative size of the fore- and hind-body, position of the ovary and testes, and anterior extent of the vitellaria The new species is distinguished from *ambloplitis* by the absence of a neck-like region in the hind-body, relative size of the fore- and hind-body, position of the testes, more anterior extent of the vitellaria, and smaller size of its eggs *C gracilis* is separated from *stunkardi* n sp, on account of the slender hind-body, position of the ovary and testes in the posterior third of the body, and restriction of the vitellaria to the posterior half of the body The present species differs from *cochleariformis* in the relative size of the fore- and hind-body, oral sucker being larger than the acetabulum, position of the ovary and testes, posterior extent of the vitellaria, and smaller size of the eggs

Host *Halcyon smyrnensis fusca*
Habitat Small Intestine
Locality Allahabad

The author is greatly indebted to Dr H R Mehra for his valuable help and advice

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CHEMICAL EXAMINATION OF THE ESSENTIAL OIL OF *OCIMUM CANUM* SIMS

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SUMMARY

1. The shrub *Ocimum canum* Sims contains on an average 0·7 per cent of essential oil, which can be easily removed from it by steam distillation.

2. The rectified oil of *Ocimum canum* is a pale yellow oil with an intense and pleasant smell of lemon with a touch of lavender.

3. The oil was found to contain over 68 per cent of aldehydes calculated as citral on estimation by two different methods.

4. The oil was resolved into aldehydic and non aldehydic constituents by aqueous sodium bisulphite. From the aldehydic portion, small quantities of methylheptenone and citronellal together with a large proportion of citral was isolated, whereas from the non-aldehydic portion, linalool, a mixture of geraniol and citronellol and also esters of these alcohols were isolated.

5. The essential oil of *Ocimum canum* appears to be a good source of citral from the commercial point of view. As it is, it could be used as an excellent perfumery material, having a persistent and delicate fragrance.

Ocimum canum Sims, or Mamri or Ram Tulsi as it is known in Hindustani, is a strongly scented low shrub belonging to the natural order of Labiatæ. It grows wild on the river banks and moist places during the rainy season throughout the United Provinces and it also grows abundantly in the foothills of Kumaun and Nepal. The mature plants are about two feet high and are much branched and pubescent. The plants attain maturity by about October or November, and after that they either die out gradually or get eaten up by cattle.

The plant has been described by Roxburgh[2] and also by Kirtikar and Basu,[1] and so a description of the plant is omitted here. Two photographs of the plant however are reproduced here in order to give a clear idea of the appearance and characteristics of the plant.

The plant is highly medicinal. A decoction of the leaf is beneficial in disorders of the digestive system, particularly stomach troubles. A paste of the leaves with water applied to the hands and feet in case of fever keeps the extremities warm. The same preparation is used in various affections of the skin, such as ringworm, scabies, eczema &c. with highly beneficial results.

Fig 1

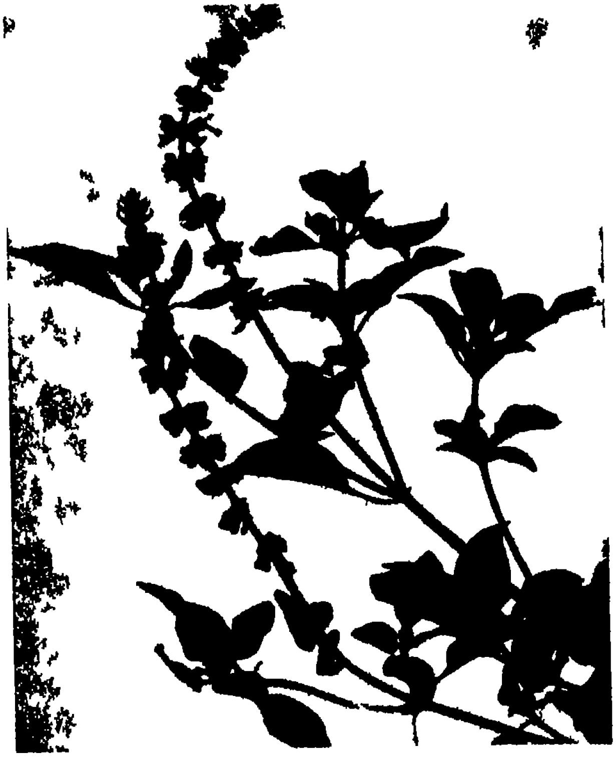

Fig 2

The plant is very rich in essential oil, the average plant containing nearly 0 7 per cent of the substance As the essential oil appears to be the main active principle of the plant and responsible for most of its medicinal properties, it was submitted to a systematic chemical examination As the result of this investigation, the essential oil of Mamri was found to consist of about 68 per cent of aldehydes and ketones, 18 per cent of alcohols, 5 per cent of esters and 2 per cent of complex hydrocarbons, all belonging to the terpene series A few minor constituents of the oil could not be properly isolated or identified for want of sufficient material.

EXPERIMENTAL

Crude essential oil of Ocimum canum.—The essential oil of *Ocimum canum* was obtained by distillation of the whole plant in lots of 3 kilos at a time, cut up into small bits by means of a chopper, with water from a large copper distillation apparatus of 10 litres capacity and fitted with a copper condensing worm, and continuing the distillation until the distillate which was milky at first began to run perfectly clear The distillate (5 litres) was shaken with petroleum ether in a large separating apparatus and the upper petroleum ether layer after dehydration was distilled from an electric waterbath until the solvent no longer came over The residual oil was a clear pale yellow liquid with an intense and characteristic smell of lemon with an appreciable note of lavender

Crude essential oil of *Ocimum canum* is pleasant smelling liquid which does not solidify even on strong cooling It is clearly soluble in 70 per cent alcohol The substance contains a large proportion of citral, as is evidenced by the fact that when treated with semicarbazide hydrochloride and sodium acetate in 70 per cent alcohol, the semicarbazone of citral (M P 135°C) crystallises out from the mother liquor in an yield of nearly 70 per cent. With a saturated solution of sodium bisulphite the crystalline bisulphite compound of citral is immediately formed which can be recrystallised from hot water in glistening snowwhite spangles

Rectification of the crude essential of Ocimum canum.—The crude oil was distilled from a small distilling flask with a short rectifying neck below the delivery tube at the ordinary pressure The following fractions were collected, the mercury thread of the thermometer shooting up in between the different ranges of temperatures indicated

Table I

Total quantity taken = 94 c c

Fraction No	Boiling range	Quantity of distillate
1	Upto 130°C	6 c.c.
2.	200-235°C	82 c.c.
3.	255-265°C	4 c.c.
4. Residue (nonvolatile)		2 c.c.

Fraction No 1 was found to be the tail fraction of petroleum ether which tenaciously adhered to the oil and did not distill off from the water bath

Fraction No 2 was the main rectified essential oil of *Ocimum canum* containing citral as the main constituent.

Fraction No 3 was a high boiling terpene hydrocarbon which had properties closely allied to *caryophyllene*, and was perhaps identical with it, but it could not be definitely identified for want of an authentic sample of caryophyllene

Fraction No 4, that is the dark nonvolatile residue, was apparently a very impure and complicated substance It solidified to a resinous mass on cooling and standing

Fraction No 2 was estimated for citral content by the sodium bisulphite method of Tiemann[3] and was found to contain 68 7 per cent of citral Quantitative estimation by the semicarbazone method also gave practically identical results From this it became quite evident that rectified essential oil of *Ocimum canum* contains over 30 percent of non-aldehydic constituents which could not be satisfactorily separated by the ordinary methods of fractional distillation Chemical method of separation was therefore taken recourse to in the following manner —

82 c c of the oil was shaken in a separating funnel with a dilute solution of sodium bisulphite (10%) Much of the oil went into solution, but the insoluble portion formed a layer on top of the aqueous solution 30 c c. of petroleum ether was added, and the top layer separated from the aqueous portion The former was thoroughly washed with water, dried and distilled from a water bath until free from petroleum ether This was labelled *Fraction No 5*

The aqueous layer was acidified with dilute sulphuric acid in the cold and extracted with petroleum ether The ethereal extract was washed with dilute sodium carbonate and water, dried and freed from petroleum ether on a water bath The residue was labelled *Fraction No 6*

Fractional distillation of the non-aldehydic portion (Fraction No 5) —

Table II

Total quantity taken = 24 c c

Fraction No	Boiling range	Quantity of distillate
7	170-175°C	1 c c.
8.	195-200°C	9 c c
9.	225-230°C	6 c c
10.	240-245°C	4 c c.
11	265-270°C	1 8 c c
12 Residue		1 5 c c.

Fraction No 7 could not be identified.

Fraction No 8 was linalool and gave identical mixed boiling point with an authentic specimen of the substance. Chemical tests also pointed to the same conclusion.

Fraction No 9 was a mixture of geraniol and citronellol which could not be separated by further distillation The mixture however could be completely acetylated by acetic anhydride and estimated as esters by Koettstorfer's method

Fraction No 10 was a mixture of esters, most probably of geraniol and linalool From the ester value found by actual experiment and calculated as geranyl acetate, the product consisted of 97 2 per cent of esters.

Fraction No 11 was pale green in colour, and was found to be a terpene hydrocarbon On account of the small quantity at our disposal, it could not be identified

Fractional distillation of the aldehydic portion (Fraction No 6) —

Table III

Total quantity taken = 56 c c

Fraction No	Boiling range	Quantity of distillate
13	170-175°C	2 c c.
14	205-215 C	6 c c
15	225-230°C	49 c c
16	255-260°C	1 c c
17 Residue		0 5 c.c

Fraction No 13 appeared to be methyl-heptenone although the semicarbazone prepared from it melted at 5 degrees below the melting point of pure methyl-heptenone-semicarbazone (134°C)

Fraction No 14 was identified to be citronellal by formation of citronellyl-β-naphthocinchoninic acid (M P 225°C) with β-naphthylamine and pyruvic acid.

Fraction No 15 was identified to be citral or rather a mixture of α and β citrals The semicarbazone prepared in the usual manner melted at 135°C and the melting point and properties of the substance were identical with those of citral-semicarbazone prepared from an authentic specimen of citral obtained from Messrs E. Merck.

Fraction No. 16 was a terpene hydrocarbon which could not be identified.

Rectified oil of *Ocimum canum* therefore contains the following ingredients in the proportions indicated below, the total quantity of oil taken for analysis being 92 c.c

Table IV

Constituents	Volume of fraction	Percentage in the oil
Linalool	9 c.c	10·9
Esters	4 c.c	4·8
Geraniol and citronellol	6 c.c.	7·3
Methylheptenone	2 c.c	2·4
Citral	49 c.c	60·0
Citronellal	6 c.c	7·3
Unidentified	4 c.c	4·8
Residue	2 c.c.	2·4

We beg to express our best thanks to Prof K P Chatterji for his kind interest in the work.

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THE
NATIONAL ACADEMY OF SCIENCES
INDIA

BUSINESS MATTERS
1938

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Allahabad University, Allahabad

His Exalted Highness The Nizam of Hyderabad (Deccan)

The Hon'ble Sir Shah Muhammad Sulaiman, Kt., M.A., LL.D., D.Sc.
Judge, Federal Court of India, New Delhi

ANNUAL MEETING

The Annual Meeting of the National Academy of Sciences, India, was held in the Vizianagram Hall, Muir College Buildings, Allahabad, at 3 P.M., on Saturday, February 4, 1939. The Hon'ble Sri Sampurnanand, M.L.A., Minister of Education, the United Provinces, presided over the function. Dr. P. L. Srivastava, M.A., D.Phil. (Oxon.), one of the General Secretaries, presented the Annual Report of the National Academy of Sciences, India.

Sir Shah Muhammad Sulaiman, Kt., M.A., LL.D., D.Sc., the President of the Academy, read his address. The Hon'ble Sri Sampurnanand, M.L.A., Minister of Education, the United Provinces, then delivered his address.

Prof. A. C. Banerji, M.A., M.Sc., I.E.S., proposed a vote of thanks to the Hon'ble Sri Sampurnanand and Dr. K. N. Bahl, D.Phil., D.Sc., seconded the vote.

SECRETARIES' REPORT

PRESENTED AT THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES, INDIA, ON FEBRUARY 4, 1939

BY P L SRIVASTAVA, M A., D PHIL. (OXON)

We have the honour to submit the following report on the working of the Academy during the period beginning from the 1st of January, 1938, and ending with the 31st of December, 1938.

The Seventh Annual Meeting of the Academy was held on Saturday, the 5th March, 1938, at 3 p m. in the Vizianagram Hall, Muir Central College Buildings, Allahabad. Pandit Jawaharlal Nehru presided over the function Dr P. L Srivastava, one of the General Secretaries of the Academy, presented the annual report

After Prof. B Sahni, D Sc., Sc.D, F.R.S., the President of the Academy, had delivered his address, Pandit Jawaharlal Nehru addressed the Academy

In connection with the annual function a popular exhibition was also arranged to which exhibits were sent by many prominent scientists and Government institutions of the country

A conversazione under the presidentship of Pandit Jawaharlal Nehru on Power Supply in the United Provinces was also organised, many scientists contributed papers and took part in the discussion Earlier in the day, as a part of the annual function, Rao Bahadur B Viswanath, F I C, F C S, delivered a lecture on Modern Developments in the Science of Soil and Plant Nutrition.

We are sorry to record that in the beginning of the year Prof. B. Sahni, D.Sc., Sc.D., F.R.S, expressed his inability to carry on the duties of the President of the Academy on account of excess of work and made a request that he may be relieved of the office The Council with great regret acceded to his request. Sir Shah Muhammad Sulaiman, Kt., M A., LL.D., D.Sc., was unanimously elected President of the Academy for the residue of the term

The departure of Prof M N Saha, D.Sc , F.R.S., from Allahabad, subsequent to his appointment as Palit Professor of Physics, University College of Science, Calcutta, has meant a great loss to the Academy The Academy not only owes its very existence to him, but it has also attained its present strength and status because of his fostering care and guidance The work done by Prof Saha in establishing the Academy is enough to perpetuate his association with us, the city of Allahabad and the United Provinces.

We are glad to be able to record that the Academy has made steady progress both as regards its membership and the standard of its publication The Academy has now on its rolls 176 members It is gratifying to note that our members are drawn from every part of the country We consider the elections of His Exalted Highness the Nizam of Hyderabad and Sir Shah Muhammad Sulaiman as Benefactors of the Academy during the year as an event of happy augury, they have donated individually more than one thousand rupees to the Academy, and we hope that their example will be followed by others In accordance with the rules of our constitution we elect out of our members a certain number as Fellows on account of their special distinction in scientific work The present number of our Fellows is 91 including 2 elected during the year Of our members 49 are Fellows of the National Institute of Sciences of India.

The Proceedings of the Academy have maintained their high reputation both in and outside the country The papers published in the journal have been widely appreciated and abstracted in all important Scientific Abstracts We are now receiving 170 foreign and Indian scientific journals in exchange We have published four issues of the Proceedings containing 19 papers During the year under review the number of papers communicated to the Academy was 45

It is a matter of special gratification that we have been able to publish an important booklet containing papers communicated to the Conversazione on Power Supply It is a very timely publication as the problem of National Planning is being seriously investigated and it is hoped that the booklet will be found useful to the specialist as well as to the general public Our thanks are due to the U P Government for a grant of Rs 500 towards the cost of the publication of the booklet.

Of the distinctions conferred on the members of the Academy may be mentioned the General Presidentship of the Indian Science Congress held during the current year by Prof J C Ghosh, D Sc, a Fellow and a member of our Council Prof B Sahni, D Sc., Sc.D., F R.S., our outgoing President, has been elected President of the next Indian Science Congress Prof K. N Bahl, D Phil., D.Sc., our second President, has secured the rare distinction of being the first Indian to be admitted to the degree of Doctor of Science of the Oxford University Three of our members have been admitted to the Fellowship of the National Institute of Sciences of India. Three of our members, Prof M N Saha, Prof J C Ghosh and Prof V S. Dubey, have been nominated members of the National Planning Committee appointed by the President of the Indian National Congress It is very gratifying, indeed, to record that various Governments, the Indian National Congress, industrialists, businessmen and the general public, are increasingly realizing the value of science and scientific researches for the well-being and uplift of the masses, The financial position of the Academy, we are sorry to say, has not been as sound as one could wish We are thankful to the Government of the United Provinces of Agra and Oudh for the grant we have been receiving from them for the last several years We also gratefully acknowledge the grant of Rs 500 by the Imperial Council of Agricultural Research, New Delhi, for the third year in succession We are highly indebted to His Exalted Highness the Nizam of Hyderabad and Sir Shah Muhammad Sulaiman for their donations of Rs 1,000 and Rs. 200 respectively during the year We earnestly hope that the Allahabad Municipal Board which is interested in the affairs of the Academy will also make a suitable grant.

The paucity of funds has stood in the way of enlarging our activities or taking up any new programme of work Our finances do not permit us to enlarge the size of our proceedings or to organise a properly equipped Science Library or to open exchange relations with many foreign scientific societies The need for a building of the Academy in which we can house our library and hold our meetings is urgently felt. We appeal to all who consider scientific advancement as essential to the country's progress to help the Academy so as to enable us to enlarge and extend its activities All the meetings of the Academy were held at Allahabad during the year We are anxious to hold meetings in other places as well It is hoped that, with the increase in the number of members residing at other academic centres, the meetings will in future be held at other places also.

The Education Minister's Gold Medal has been awarded this year to Prof B. Sahni, D Sc., Sc.D., F R.S, Professor of Botany, Lucknow University, for his paper on Materials for a Monograph of the Indian Petrified Palms

Dr U N Chatterji continued to be the Special Officer of the National Academy of Sciences, India, throughout the year

It is a great pleasure to us to record that the constitution of the Academy as drawn up by Prof Saha and his colleagues eight years ago has worked with great success.

Before closing, we the General Secretaries, wish to offer our grateful thanks to the successive presidents, the members of Council and the general body for their active help and co-operation in the discharge of our duties In their generosity they have allowed us to act for full four years, the maximum period permissible under the rules, and we thank them for this mark of confidence in us We are also grateful to Dr U N Chatterji, our Special Officer, and Mr P C Mukerjee, our office clerk, for their zealous and ungrudging co-operation.

ADDRESS OF THE PRESIDENT—THE ULTIMATE STRUCTURE OF MATTER

DELIVERED AT THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES, INDIA, ON FEBRUARY 4, 1939

BY THE HON'BLE SIR SHAH SULAIMAN, KT., M A., LL.D., D Sc.

It is only natural to believe that the Greeks must have obtained knowledge of the philosophy just as that of astronomy which had existed in the older Babylonian and Egyptian civilizations, with which their close contact is indisputable

Not only the Neopythagorean Noumenios (fr 13, R.P 624) had acknowledged this indebtedness to the East, but also Clement (Strom i. p 8, 5 Stahlin) conceded this. The Encyclopædia equally admitted the benefits derived from Oriental wisdom. Bailly (Letters sur l'origine des sciences) agreed that the Oriental had received in legacy a highly advanced science from a people who had disappeared, and whom he however identified with the inhabitants of Plato's Atlantis Up to the 19th century Roth and also Gladisch recognized that the Greeks owed much to the East.

PHOENICIAN PHILOSOPHERS

The Nature philosophers of Asia Minor, from THALES (580 B C ٹالیس) onwards, had pondered over the question of what the world was made of The first idea naturally was that there was some primary element which was the essence of all things

There is the good authority of Poseidonios, quoted by Strabo (XVI, p 757) to prove (though attempts are now being made to deny it) that the Phoenician philosopher MOCHU or MOSCHUS (موسی) of Sidon first originated the atomic philosophy long before even the Trojan wars He is referred to in an ancient Phoenician history by Sanchuniathon, published by Philon of Byblos, which was used by Porphyry and later by Eusebios.

THALES, who on the authority of Herodotus was undoubtedly of Phoenician descent, had unquestionably introduced the Egyptian geometry and arithmetic into Hellas, and was certainly familiar with the Babylonian astronomical records, as he had predicted that a Solar eclipse would occur by a certain date in Asia Minor (the eclipse of May 28, 585 B.C) He could not possibly have located the eclipse in Asia Minor on the basis of Egyptian records, as has been suggested by some. THALES was the founder of the Milesian School and therefore the first man of Greek science. Only a few fragments of his philosophy are now available, but it is certain that he believed in a material cause of all things, though apparently he identified that with water.

GREEK PHILOSOPHERS

Aristotle (340 B.C ارسطو) in fact contrasted Thales with **ANAXIMANDER** (546 B.C انکسیمندر), who had maintained that the primary substance was infinite, and the world was an endless mass stretching out without limit on every side **ANAXIMENES** (526 B C انکسیمانس) held that the underlying substance was one and infinite, but determinate, and asserted that this primary element was air, which when rarefied became fire, when condensed became water, and then earth when condensed still more (and to hard stone if condensed still further)

HERACLITUS (502 B.C ہیراکلیتس) conceived that the primary element was aetherial fire which is the fundamental stuff of which all objects are made and to which they all ultimately return

ANAXAGORAS (540 B C انکساغورث), an Ionian philosopher, preached that all things were together infinite both in number and smallness, and so there is not a least of what is small, but there is always a smaller, and what is cannot cease to be by being cut He took a materialist view and postulated that matter was composed of different entities, each having different qualities The proportions in the various ingredients may differ, but the division, no matter howsoever far it be carried, would leave the parts similar to the whole in their contents There were no coming into being or passing away, but merely mingling or separation of things

PYTHAGORAS (530 B C فیثا غورث) of Samos gave up the earlier conception of one single element being the basis of all structure, and propounded that matter was composed *of four elements.* But Pythagoras had not denied void and had in fact presumed the existence of a great void outside the world

EMPEDOCLES (450 B.C امپیدق کلیس) of Akrogas (believed to have been founded from a Rhodian colony), who belonged to the Pythagorian School, formulated the conception more elaborately and regarded the Universe as consisting of four fundamental and eternal roots or primary elements, namely, earth, water, air and fire, corresponding to solid, liquid, gas, and one other still more refined kind of substance These elements were combined under divine powers By a variety of combinations the different types of matter were formed These four elements were believed to be derived from the four fundamental qualities—hot, cold, wet and dry The transformation of substances from one kind to another convinced the ancient philosophers of the indestructibility of matter

The Greek philosopher **LEUCIPPUS** (لیوسپس) gave definite shape to the Atomic theory in the 5th century B.C and assumed innumerable and ever-moving atoms, with infinite forms. He laid down that the substance of the atoms was compact and full ("what is"), while they moved in the void ("what is not") both being equally real

His pupil **DEMOCRITUS** (دیمقراطیس), more famous than his master, consolidated the theory known after his name about 420 B.C The atoms of Democritus, as handed down to posterity by Epicurus (341—270 B.C ابیقورس) and Lucretius (قراطیس) were existent from eternity, never created and never annihilated. They however differed in their sizes and shapes, but were identical in substance, and were all single, solid, indivisible particles. The differences in the properties of various types of matter were the results of the differences in their size, shape, position and movement. In solid bodies the atoms oscillated within narrow ranges whereas in air they could rebound to longer distances While moving in all possible directions through the void space, they struck each other, and their collisions produced further movements, sometimes leading them to combine so as to form composite elements Worlds formed out of these may grow, decay or perish, but their ultimate constituents were indestructible, their sizes were permanent and their shapes inviolable

Leucippus believed that Atoms were too minute to be divided, Democritus believed that they were too hard to be broken He however allowed them all sizes Epicurus believed that they were too small to be seen and too hard to be broken, and added weight to the atoms

The opposite school denied the existence of such ultimate particles and could not understand how a further sub-division could stop If there was any solid particle occupying a definite volume in space, its theoretical sub-division was obvious, and therefore its actual physical sub-division could not be impossible They refused to believe that the process of sub-division could not be carried on further and must stop at some unknown and definite stage

Plato (360 B C افلاطون) asserted that each of the four elements, fire, air, water and earth, was composed of geometrically regular particles Particles of fire were regular tetrahedra (i e, four exactly equal equilateral triangles forming the four faces) The particles of air were octahedra (i e, eight equal equilaterally triangular faces). Twenty such equal equilateral triangles were the twenty faces of a particle of water which was an icosahedron The particles of earth however were cubes with six square faces These could never take any other form and so were indivisible and indestructible But the other three elements could be transformed into one another Plato denied the existence of the vacuum and the void, and asserted that the particles fitted each other perfectly

Aristotle (384—322 B C ارسطو) did not accept the indivisible atoms of Democritus and held that there would be a serious anomaly if atoms had parts and yet could not be divided, although theoretically he was forced to concede that Nature might in fact refrain from dividing such atoms though they had parts to divide He thus admitted that potentially divisible matter might actually be indivisible, and that wholes could have properties that their parts did not possess individually, and so a group of atoms might be richer in qualities than any one of its constituents But the void of the Atomists was altogether incredible to Aristotle Aristotle, following Plato, revived Anaximander's conception of continuous substance without interspaces.

Plutarch (فوطرخس) in the 1st century after Christ argued "How could there be heat if no atom were hot, or colour or sweetness if atoms were neither coloured nor sweet—how could such qualities be generated from the meetings and conjunctions of qualitiless atoms? Neither sense, nor soul, nor understanding, nor prudence could issue from atoms—and atoms could not spring from the bare void"

The main objections to the indivisibility of atoms may be summarised as follows —

(1) indivisible particles, with parts, was a self-contradiction,
(2) voids or inter-spaces were wholly incredible,
(3) atoms with only shape, size, solidity and motions or even weight were incapable of producing other qualities,
(4) a mere group of distinct and separate atoms could not produce this world of colour, scent, sound and taste, and
(5) it was absurd to imagine that living things were derived from inanimate atoms

The destructive criticisms of Plato and Aristotle, although based purely on theoretical grounds, suppressed the Democritean theory for centuries, and it became the universal conviction that there was no vacuum in Nature

HINDU PHILOSOPHERS

The Hindu conception of matter according to Nyaya-Vaicesika during the early centuries of the Christian era (as recently presented by Umesha Mishra) was that matter comprised eight forms, five discreet and three ubiquitous in nature Matter of the first kind consisted of four productive elements *(Maha-bhutas)* and Mind *(Manas)*, conceived as an eternal substance and associated with an individual The second kind was a continuum, both substantive and eternal, *viz*, time and space The four primary elements were the Greek elements, earth, water, air and fire Each of the four fundamental elements consisted of ultimate particles of matter *(Paramanu)* The Paramanus did not possess magnitude and so could not be perceived, their existence could only be inferred The proof that they were indivisible by nature and incapable of further analysis followed the Greek reasoning that the possibility of further division would lead to a *regressus ad infinitum*, because as every such component would consist of equal endless number of constituents, there would be no actual difference in the dimensions of the various varieties, so that the dimension of the highest mountain would be equal to that of a mustard seed, which was impossible The principal attributes of Paramanu were that they were (*i*) eternal, (*ii*) indivisible, (*iii*) dimensionless, (*iv*) incapable of producing anything by themselves, (*v*) incapable of being perceived through the sense organs, but (*vi*) they possessed quiddity which differentiated one from another They also possessed (*vii*) certain specific attributes—the airy ones possessed touch, the fiery ones possessed touch and colour, the watery ones possessed touch, colour and taste, and the earthly ones possessed touch, colour, taste and smell

The Nihilist school of the Buddhist held that Void was the only real entity and that the eternal existence of a substance, which had no constituent part, was inconceivable, because the ubiquitous kind of matter must permeate Paramanus, both in and out, and therefore the Paramanus must have parts and be non-eternal As objects, having form and touch sensation, occupied space and possessed parts, so a Paramanu, which also possessed a limited form and touch sensation, should occupy space and therefore had parts

MUSLIM PHILOSOPHERS AND THINKERS

Among the Muslim scholars there were four main schools of thought (1) On the one extreme were the theologians (ظاہری) who emphasising the limitations of human intellect maintained that it was beyond human power to find out the hidden essential nature of things, and that religion was principally a matter of faith and must be accepted as revealed, (2) on the other extreme were the philosophers (فلسفہ - حکماء) who drew a sharp distinction between religion (الہیات) and Physics (طبیعیات) and considered religion as being associated with an inward mental power, and not a branch of intellectual knowledge, which can be reduced to a system of logical or philosophical propositions, (3) in between came the rationalists (معتزلی) who treated reason as the ultimate authority and indeed the main source of religion also, and tried to reason out all religious dogmas, creating their theology solely by reason and rejecting all that did *not conform to their own reason*, and (4) the dialecticians or Mutakallemin (متکلمین), who defended the religious truths by logical arguments, did not shirk a critical inquiry into metaphysical concepts and offered new solutions of the philosophical problems Of these the first were traditionists, pure and simple, and altogether refused to discuss philosophical problems The second upheld the Aristotelian conception of the structure of matter, denying the indivisibility of matter and the existence of vacuum The third group also were inclined towards the same view The fourth however favoured the Democritean conception, rejected the infinity of division, and accepted the existence of indivisible corpuscles and the possibility of void or empty space, and made their own original contribution that the ultimate composition of matter was non-material

Among the early philosophers may be mentioned ABU NASAR FARABI (ابونصر فارابی), AVICENNA (ابو علی ابن سینا), IBNUL-RUSHD (ابن الرشد) and Mohaqqiq TUSI (محقق طوسی), MULLA BAQAR (ملا باقر), the author of Ufqul Mobin (افق المبین), Asiruddin Mufzil (اثیرالدین مفضل), author of Hidayat-i-ul Hikmat (ہدایۃ الحکمۃ), Husain Maibazi (حسین میبذی), author of Maibazi (میبذی), Mohammad Ibni Ibrahim SADRUDDIN (محمد ابن ابراہیم صدرالدین) of Shiraz, (d. 1050 A.H), author of Sadra (صدرا), and the greatest Indian Muslim philosopher MULLA MAHMUD (ملا محمود) (d 1062 A H.) of

Jaunpur, the author of *Shams-i-Bazigha* (الشمس البازغه), regarded as the most advanced book on Physics in the Nizamia School, adhered to the Aristotelian view

According to the philosophers a material body (جسم مادی) consists of two things—(1) the substance or stuff (مادہ-ھیولی) of which it is made, and (2) the form (صورت جسمیہ) which it assumes This substance is neither in itself (بنفسہ) always continuous nor in itself separate, neither always single nor multiple but it can assume all characteristics. Portions of any element can be separated (*e.g.*, part of water), but when any separate portion is considered, it is continuous, without any interspaces and so can be divided and sub-divided *ad infinitum* This substance is not perceptible without a form, both must exist together Thus the substance has perfect extension, and is therefore capable of infinite division Existence of indivisible particles or of vacuum has no meaning

After GHAZZALI (1058—1111 A.D امام غزالی), the real founder of the Mutakallemin School, may be mentioned NAZZAM (نظام) who was really a Mutazili, Fakhruddin RAZI (فخرالدین رازی), TAFTAZANI (تفتازانی), author of *Sharah Aqaid Nasafi* (شرح عقائدنسفی) and *Sharah Maqasid* (شرح مقاصد), Syed Sharif JARJANI (سید شریف جرجانی), author of *Sharah Mawaqif* (شرح مواقف) and *Mohakamat* (محاکمات), Abdul Karim SHAHRASTANI (عبدالکریم شہرستانی), the author of *Al-milal wa-al-nahal* (الملل و النحل), ASFARINI, the author of *Sharah Aqaid Asafarini* (شرح عقائداسفرینی)

The Muslim Dialecticians believed that nothing could be either eternal or infinite except God, and that an infinite divisibility of matter was impossible. Agreeing with the Philosophers they held that matter in this world was formed out of 4 primary elements (عناصر) fire, air, water and earth (later reduced to the "principles" of (*a*) Sulphur, *i.e.*, combustible and disappearing by burning, (*b*) Mercury, *i e*, distilling over as liquid and (*c*) Salt, *i e.*, solid residue), but that each of these was ultimately indivisible According to them a body (جسم) had length, breadth, thickness as well as other qualities like colour, scent, hardness, etc A body consisting of any of the primary elements was not absolutely continuous in its inner structure, and was therefore not infinitely divisible There were ultimate corpuscles in the body which could not be sub-divided into smaller material particles. But this ultimate particle was composed of two or more non-material units of essence (جوہر) which in themselves were indivisible (جز لایتجزی). These entities were not material particles at all, and so did not possess the qualities of size, weight, volume, etc, which material bodies possess, and length, breadth and height not being associated with them they were incapable of further sub-division—this *jauhar* was an indivisible unit, incapable of being sub-divided either theoretically, or practically by breaking or even in imagination The Democritean atoms were indivisible particles of matter of certain sizes and shapes which could theoretically though not in fact be sub-divided. But these entities were different not being material at all, and the question of their sub-division did not arise. The universe was not continuous in its structure, and its ultimate indivisible constituents were separate from one another, though the gaps between them were too fine to be within human perception When however these indivisible entities combine together so that they become contiguous, a new property of continuity, besides their grouping, appears, and they assume the form of matter

There had, however, been three slight divergences from the general views of the Mutakallemin

(1) Nazzam (who was a Mutazili) had maintained that a body is in fact composed of an infinite number of particles without any limit.

(2) Shahrastani asserted that the particles were limited in number also, and that they might have been divisible, but are not in fact so

(3) Qazi Abu Bakar Baqilani (قاضی ابوبکر باقلانی) considered that when the entities combined to form a body, there was merely a group of entities, and nothing new came into it But the general opinion was that something new came into the grouping by reason of the contiguity of the entities

The Muslim Dialecticians repudiated the conception of infinite sub-division of matter, but the ultimate composition of matter was not matter (جسم مادی) with volume or size, but something ethereal—sizeless and shapeless, and therefore incapable of further sub-division, although it had position In *Sharah Mawaqif* (Vol VII, p. 6) the opinion of Shahrastani is quoted that material particles are not capable of an infinite division, and that ultimately a stage is reached when they cannot be divided into smaller material particles, but that further sub-division would make matter disappear altogether and pass into the form of *Jauhar* The ultimate constituent (جوہر) was indivisible both physically and theoretically and did not possess even the other qualities of matter like weight, size and shape, etc. This ultimate constituent was more like some primary essence, *e g.*, energy of modern days Thus matter ultimately resolved itself into *jauhar* , in the last division matter with most of its properties disappeared altogether, and only *jauhar* remained, which was an essence of quite a different nature This *jauhar* was not a material substance at all , no doubt it was a unit, but it was dimensionless

A clear distinction was drawn between substance (عین-مادہ) and quality (عرض)—the former is that possibility which exists in its own entity without dependence on the existence of any other thing, but the latter is mere accident, which must exist in some substance, whereas a quality cannot according to the majority of the opinions exist in another quality Of course, all substances have some qualities, and so they exist together , but qualities can vanish or can be replaced by others. Indeed, qualities of substances are constantly changing

The Muslim Dialecticians did not regard time as if it was flowing continuously like a stream , but considered its passage in units of time, which involved a theoretical discontinuity As qualities change from time to time they were considered to be fleeting and transitory There was thus an endless series of appearances, disappearances and re-appearances In that limited sense there were alternate destruction and creation. Some of the early Mutakallemin, like Nazzam, interpreted this as if the world was being destroyed and recreated by God in every unit of time, and this has been freely reproduced by European scholars as the basic doctrine But the general opinion even among these early Muslim thinkers was of a practical continuity of existence and a regular uniformity What was really meant was that the progressive development was under the direct will of God, and God could destroy it if He so wished.

For purposes of illustration one criticism, reply, rejoinder and counter-reply may be quoted —

P Suppose we place one indivisible atom between two indivisible atoms, then the middle one will (1) either not prevent the right one from touching the left one or (2) it will do so In the first case, it will penetrate into them, and then volume cannot be increased. In the second case there is obviously a division of the middle one as it separates the other two from touching each other

M. The first case is not possible as there is no such penetration The second case merely involves a distinction of the right and left sides, not a division of the middle particle itself

P But the position where the right side is situated is different from the position where the left side is situated Otherwise reference to one will necessarily imply a reference to the other which is impossible Hence a division follows

M If you assume that the two sides in fact occupy different places, then this is wrong as we make no such assumption And if you merely imagine them as occupying different places, though not in fact so, even then it is wrong, because this is a self-contradiction

It will thus appear that the Philosopher's criticisms proceeded on the assumption that the indivisible atom has some size, the Mutakallemin's reply is that it is dimensionless Their favourite illustration is the geometrical point which can have a point on its right and another on its left, and yet is in itself indivisible

The attack of the philosophers on the Mutakallemin's position could be easily met

(1) The criticisms had been directed exclusively against the theoretical indivisibility, and not indivisibility as a fact in Nature

(2) The criticisms were futile when the indivisible entity was dimensionless

(3) The conception of void interspaces was easier than that of a perfect continuity.

(4) Production of different properties by a combination of indivisible entities was more likely than such production by a single continuous substance

(5) Life was something quite distinct from inanimate matter and could not spring up from the one continuous substance, whereas spiritual entities could manifest themselves

The Mutakallemin's conception of the Universe being of grained structure, composed of non-material units, neither continuous nor infinitely divisible, was certainly an original contribution to philosophy But the opinion of Avicenna, who was a recognized authority even in Europe for centuries, founded as it was on the high authority of Aristotle, eclipsed the contrary view during the Middle Ages, and was universally adopted We find nothing but a vague reference made by Maimonides to the Mutakallemin's hypothesis

EUROPEAN PHILOSOPHERS AND SCIENTISTS

It was **DESCARTES** (1596—1650) who partly resuscitated the forgotten Atomism in the guise of his Corpuscular Philosophy Although he took the whole material universe to be one infinite and perfectly continuous stretch of extended matter, without any interstices whatsoever, and denied any void that did not contain such extended matter, he considered it to be a granulated continuum, diversified into innumerable different corpuscles and controlled by Divine Hand These corpuscles could stream through the material continuum and also through one another The corpuscles were both divisible and deformable, though some might remain intact. This new Philosophy could assume a continuous stretch of matter, dispense with voids, admit divisible particles and also recognise divine control

LEIBNITZ (1646—1716), with a slight variation, adopted the Mutakallemin's conception of indivisible entities As pointed out in the Encyclopædia Britannica "Leibnitz's world consists of monads which are immaterial centres of force, each possessing a certain grade of mentality, self-contained and representing the whole universe in miniature and all combined together by a pre-established harmony. Material things are in their ultimate nature composed of monads, each soul is a monad and God is monas monadum This monadism is a kind of spiritual atomism"

ISAAC NEWTON (1642—1727) agreed that the stability of the world required inviolable particles, and believed that God had in the beginning created matter in solid, massy, hard, impenetrable, and movable particles of different sizes and figures, and that corporeal changes were the unions and disjunctions of these solid particles, that never wore nor broke

BOYLE (1727—1761) sought to explain the heating effect of boring by increased tumultuous corpuscular motions within the heated fragments Boyle however added corpuscular texture to physical realities.

With the advent of chemical analysis, the Atomic theory rapidly gained ground. Democritean "physical atom," the molecule, was broken into "chemical atoms," the modern atoms. Water was found to be an aggregate of similar compound atoms, or molecules, and all samples of water contained the same elements in the same proportion by weight. Each atom of oxygen in it had precisely the same weight, and all atoms of hydrogen in it were equally heavy. The necessary conclusion was that the elements in any chemical compound would always be in fixed proportions.

Dalton's Atomic Theory (1808—10), previously presumed by Higgins, gained slow but steady acceptance. He had laid emphasis on the weights of atoms. Humphry Davy had first ridiculed it, but later his own Law of Definite Proportions suggested that bodies might be composed of ultimate atoms Gay Lussac's Law of Volumes that the volumes of combining gases and of their gaseous products were in simple ratios to one another pointed in the same direction Avogadro's Law that at the same temperature and pressure equal volumes of different gases contain equal numbers of molecules obtained unanimous approval The concept of valency strengthened the idea of molecular structures

When attempts to explain valencies of various atoms by arranging them in a plane had proved unsatisfactory, van t Hoff pointed out in 1874 that molecules and their constituent atoms occupy a space of three dimensions, and so the formulæ for two dimensions were not appropriate He was able to explain some valencies on the supposition that the disposition was at the corners of a tetrahedron. With the researches of chemists like Lavoisier and Davy the number of simple elements rapidly increased

After the middle of the nineteenth century, the Kinetic Theory of Gases brought to prominence their corpuscular character Air in a closed vessel would press on a side twice as hard because its molecules would hit it twice as much, if the volume were reduced to half Mathematical deductions established clearly that the heat of a gas was the kinetic energy of its molecules, its temperature was associated with its molecular velocity, its diffusivity was its spreading molecular motions and its pressure or elasticity was the bombardment of its moving molecules.

The next step was to break open even the chemical atom, and split it up into its constituents The negative electron first forced its recognition, followed by the positive nucleus. In 1904 Nagaoka had suggested a Saturnian system of negative electrons, repelling each other mutually, and rotating round a positively charged and therefore attracting central mass for an atom This forecast had a partial fruition in Rutherford's nuclear atom of 1911, when a microscopic solar system was established in the atom Negatively charged electrons were revolving round a positively charged central mass The masses and the radii of the nuclii and the electron were determined. The hydrogen nucleus, the proton, was even more minutely minute than the electron, and yet had much greater mass The unstable atoms in Radioactive substances were constantly disintegrating Scintillations on a screen showed the scattering of alpha particles (the nuclii of helium atoms) demonstrating their existence as discreet units. They were the positive residue after the two negative electrons in each atom had left it. The Atomic number came to signify the number of positive unit charges on the atomic nucleus corresponding to the number of extra nuclear electrons. The Atomic weights represented the number of protons in the nuclii.

The circling electrons of Rutherford, as they altered their speeds or changed their directions, would radiate energy continuously, and Mathematics showed that the radiating electrons would continually approach the nucleus and ultimately coalesce into it. To get over this serious difficulty NIELS BOHR boldly suggested a discontinuity in Nature His hypothesis was that in certain definite orbits an electron could revolve without radiating any energy at all, and that these only were possible orbits for constant orbital motion without emission or absorption of energy When the electron suddenly rushed from an outer to an inner orbit, it emitted a definite quantum of energy in the form of radiation, neither more nor less, but varying from one pair of orbits to another An accession of energy could be received in definite quanta only, and then the electron suddenly rushed from an inner to an outer orbit. The permanent state of stationary energy was only in the innermost orbit of the lowest energy It has also been said that in the inner orbits the electron was spread out like a ring, in the outer orbits it contracted to a material particle The electron either emitted or absorbed a whole quantum of energy or none at all It was destined to be in one orbit or another, and there was no halfway for it. It could not even cross the space between the two orbits. Thus the Mutakallemin's discontinuity in Nature, as it were, was resurrected, and the electron could only be annihilated in one orbit and recreated in another, it could not continue its existence and cross the forbidden space in between.

SOMMERFELD substituted elliptical orbits for circular ones, and the new orbits showed a precession round the focus where the nucleus lay But the electron was still confined to definite permissible orbits, and could not at all move in the space intermediate between the prescribed orbits and only one electron was allowed to occupy one orbit.

Later, researches led to the discovery not only of protons, but also recently of positrons, neutrons and heavy electrons, and even the conception of neutrinos, each confirming the corpuscular character of matter with discreet and independent units, though extremely minute.

Thus the corpuscular theory of matter was completely restored, though the indivisibility was carried further beyond the physical molecule and even the chemical atom, right up to the electron, positron, heavy electron, proton and neutron.

SUPERSESSION OF PHYSICS AND PHILOSOPHY

Newton's corpuscular theory of light broke down when it failed to explain the phenomena of interference, diffraction and polarisation These required that if one beam of light is split up into two, and one lags behind the other, they can destroy each other, and should therefore possess some transverse periodic motion besides a longitudinal velocity Experiments have confirmed that light is an electromagnetic phenomenon. The wave theory of light explained the main phenomena, but the ether required for its propagation failed in other respects The theory broke down when the photoelectric effect was discovered. Now we have an imaginary world of four dimensions postulated in EINSTEIN'S Relativity to explain its behaviour

A similar fate has overtaken matter Electrons are known to follow tracks, like bullets, in a Wilson Cloud Chamber, and their tracks are also observed in Bucherer's Experiment. No doubt COMPTON had discovered that X-Rays colliding with electrons behave exactly as a swarm of particles and are scattered as if they were discreet units like billiard balls Again, when a stream of electrons is made to fall on a scintillating screen, they spread like dots irregularly all over it, as if a shower like separate drops of rain were falling on the screen This confirmed the corpuscular character of matter But DAVISSON and GERMER found that electrons are scattered with a peculiarity that would be due to their diffraction The closely packed atoms of a solid sheet furnish a natural diffraction grating G P THOMSON applied the principle of X-Ray powdered photograph and let a pencil of electrons fall on a thin metallic film, almost transparent, and then on to a photographic plate. The image that was produced had a central spot with circular rings round it due to the diffraction of the electrons by the small corpuscles of the metallic film Recently the diffraction of whole atoms has been observed by DEMPSTER and others. Thus electrons and even atoms must have some periodic motions. Neither the old corpuscular theory nor the wave theory which followed it can explain both sets of phenomena at the same time

Since 1925, the tendency is to throw overboard all philosophical and physical concepts and clothe the behaviour of electrons and atoms in a complex mathematical garb DE BROGLIE has introduced the idea of some kind of imaginary and artficial waves in a rather vague way HEISENBERG and SCHRODINGER have developed the new Quantum or Wave Mechanics, and DIRAC has combined the theory with Relativity We now have a mathematical theory expressed in a complex mathematical form, which however has not even the remotest resemblance to a physical theory

A new principle of Indeterminacy has been propounded, which makes it wholly uncertain how an electron will behave. It is not a mere subjective, but an objective uncertainty An electron is now supposed to be a train of waves stretching from infinity to infinity, it can be assumed to be anywhere in this train, its position is unknown, but its speed is known When however once one tries to observe it, the infinite train instantaneously contracts to a zero point; the position becomes known, but the speed becomes indeterminate The wave group must always be moving, cannot be stationary and its shape must be constantly changing The number of its crests goes on increasing with time The train of waves representing an electron goes on spreading continually from infinity at one end to infinity at the other, but the moment the electron hits anything, its whole infinite train immediately contracts to a zero point. The group wave is the mathematical successor of the point charge. But the conception of an infinite train of waves, which instead of scattering away further and further, as waves must do, suddenly converges to a point is devoid of all physical picture

And these artificial infinite trains of waves are not any real waves at all, nor even waves of energy, but mere artificial mathematical waves of Chance or Probability They are incapable of being located in space and time and are mentally incomprehensible, their only quality being that they are expressible in mathematical symbols. They are nothing more than a mere mathematical fiction Such mathematical manipulations may be a good device or a dodge, but can hardly be considered to be a physical theory The whole situation has been aptly summed up by Sir ARTHUR EDDINGTON in one sentence—"There is something radically wrong with the present fundamental conceptions of Physics, and we do not see how to set it right."

A NEW PHILOSOPHY

As the Zahiris maintained, there are undoubted limitations on the range of human vision Man's knowledge of Nature is strictly restricted both on the macroscopic and the microscopic scale With the tremendous advance of human knowledge the limits on both sides will undoubtedly be extended further and still further, but the limitations imposed on man's mental and intellectual powers make the knowledge of the absolute truths of the innermost working of Nature beyond his reach. Knowledge of the absolute Why and How can never be attainable. Man can only make conjectures and speculations, and as more facts and data become available, his theories must be modified and readjusted to fit the new discoveries This process has to go on and must go on almost indefinitely, the true reality always eluding his grasp

With the progress of centuries man's outward vision has expanded immensely With his naked eye he not only sees the solar system, but also the galactic system containing the near stars. With the help of large telescopes, even extra-galactic systems are now visible, and millions of nebulæ have been observed, the light from some of which may take 140,000,000 years to come to the Earth When the 200-inch telescope is ready, he would be able to see a million-times as much light as an unaided eye, and yet it will be impossible to say that the outermost depth of space has been fathomed. There must be a super-galaxy containing all the extra galactic nebulæ, and there may still be meta-galaxies containing millions of such super-galaxies. The gigantic dimensions of the Universe, even if limited, would, for all practical purposes, remain infinite to human observers

On the inner side the physical atom, *i.e.*, the molecule has already been split up and even the chemical atom has been broken into its constituents. We visualise the motions of electrons, protons, and observe the tracks of positrons and neotrons, and even imagine the existence of a neutrino Imagination has not yet gone further But who can doubt that there may be worlds within the smallest world that we have so far been able to contemplate There is every hope that with further progress the inner constituents of these invisible entities would be comprehended, but it will ever remain impossible to get into the absolute depths of the innermost world.

In spite of all the discoveries that have been made, the origin of life is a mystery But one fact stands out prominently Life is undoubtedly something distinct and separate from matter Life is not a mere combination or permutation of electrons and nuclii. No mere compounding of material corpuscles can result in life. Science has utterly failed to discover that life can be produced from inanimate objects All the evidence points unmistakably to the conclusion that living organisms are born from previous parents The constitution and behaviour of matter have been expressed in mathematical formulæ representing imaginary waves of chance or probability But Mathematics is helpless in evolving mathematical equations for the existence, continuance or extinction of life. Man is unmistakably conscious of his existence. There is some inner power in him which convinces him that he is not mere earth, water or air Deep reflection cannot but fail to impress upon him the belief that there is something spiritual or divine in him which is not identifiable with mere matter, and that his existence is a reality and not a fiction

The modern conceptions of Physics have led us into a *cul de sac*, and created a deadlock. It may well be that we chose a wrong path and find ourselves now confronted with anomalies and contradictions, and even absurdities We shall be driven further and further away from reality until we retrace our steps and find out the right path which would enable us to get rid of the illusory world we have invented, and to perceive something comprehensible and rational, which would present before our minds the real world.

Instead of the supposition of a discontinuity in Nature, which alone can explain the disappearance of an electron from one orbit and its sudden reappearance in another without crossing the space in between, it may well be that a lighter corpuscle after certain intervals when it has reached an unstable stage is by an internal explosion shot off from the electron and by reaction gives a backward momentum to the parent body, which behaves as if a sudden impulse has been imparted to it. This would have the necessary effect of changing the instantaneous orbit. Thus the electron after each of such emissions would begin to move from that very point in a new orbit, and not that it would jump from one to another separate orbit without crossing any space

The Wave Theory of light requiring a medium for its propagation has had to be abandoned, because the properties required of the luminiferous ether are impossible. Light has been found to possess mass, exercise pressure and hit electrons as a shower of bullets would do At the same time the Corpuscular Theory of light has broken down because of the phenomena of interference, diffraction and polarisation. It has not been possible to imagine how a swarm of particles, while travelling forward, would possess a periodic transverse motion, nor how two beams of them can destroy each other To evade these difficulties the physical concept has been altogether abandoned, and attention exclusively concentrated on mathematical equations regardless of the fact that no mental picture can be obtained. Light has undoubtedly four main characteristics (1) it has longitudinal motion, (2) it has a transverse motion, (3) its transverse motion is periodic, and (4) it is an electromagnetic phenomenon The obvious inference is that a light corpuscle is a binary system, consisting of one positive and one negative charge rotating round each other under their mutual force of attraction, the whole system travelling forward with the velocity of light. Such a structure easily fulfils all the required conditions and would explain both sets of apparently contradictory phenomena. The corpuscular character would be exhibited when light is observed in its longitudinal motion; whereas the wave character would evince itself when it is observed transversely

With the lapse of time there would be a partial mutual discharge, decreasing the electric force between the two constituents, reducing the frequency of rotation and diminishing the energy Light from distant nebulæ will in the course of its passage through space during millions of years undergo an inherent loss of energy, and therefore a decrease of its frequency without there being tremendous velocities of recession for all nebulæ away from the earth as centre and increasing with their distances from it. Indeed, the spectral shift from the nebulæ would be easily explicable even if there were a uniform, almost statical distribution of the nebulæ in the Universe

In the course of long ages while travelling through space the mutual attractive force may gradually become so feeble as to allow the two components to part company. There would be then a swarm of positively and negatively charged particles which may appear to us as highly penetrating Cosmic Rays. Again, the faster spinning Cosmic Ray and γ-Ray corpuscles, requiring greater attractive force for their stability, would on collision with atoms more easily split up into their positive and negative components than light ray corpuscles of smaller frequency

The transverse periodic effect can also be produced by a rotating magnet which an electron can be Such a double-poled magnet, like the binary corpuscle of light, can easily show interference and diffraction effects With such conceptions of the structure of light and material particles, the need for introducing imaginary mathematical waves of chance and probability, apart from the average effect of an assemblage, would altogether disappear, and light like other material particles would be a comprehensible electromagnetic phenomenon

Newton's hypothesis that the law of Gravitation remained exactly the same whether the attracting body was stationary or moving, howsoever fast, necessarily involved the assumption that gravitational influence was exercised instantaneously and therefore the velocity of gravitational propagation must be almost infinite From the assumption that material bodies were immersed in some sort of fluid ether which presses on them, Laplace deduced that the velocity of gravitation would be from the attracted body towards the attracting body and that unless the velocity were more than 6 million-times the velocity of light retardations caused in the motions of the planets in a couple of centuries would be so large as to be easily detectable But the direction of the velocity of gravitation may well be from the attracting body towards the attracted body and not the reverse, and a resisting medium may counteract the acceleration Further, Laplace overlooked the effect of the retarded potential, which must be taken into account as all the heavenly bodies are in motion and none stationary Both Lorentz and Eddington have calculated the value of such retarded potential If their formula be applied to the almost constant mass of attracting bodies, the startling result is that the first order terms vanish altogether and the perturbations, which Laplace had feared, would be practically non-existent being of the second order terms only No insuperable mathematical difficulty therefore intervenes in the supposition that the velocity of gravitation is finite or that it is equal to the velocity of light.

So far it has been assumed that Coulomb's law of electrical attraction and repulsion is absolutely exact, and that the magnitude of the force of attraction between two opposite unit charges at a unit distance apart is exactly equal to that of the force of repulsion between two similar unit charges at the same distance apart But in fact this assumption may not be exactly true, and may be only almost exactly true, leaving a small residue of excess of the attractive over the repulsive force This would result in a net attractive force between two atoms, but this extremely small difference would be imperceptible as compared to electric forces When however two large masses are considered, the combined residue of all the atoms in the two bodies would produce an accumulated attractive force, which is observed as the force of gravitation In this way gravitation can be completely identified with electricity, with which light has already been identified. Thus these three great phenomena, which appear to be different, become completely unified, and it is no wonder that they all possess the same velocity of propagation.

Nature possesses uniformity and harmony, it is only Man's knowledge that is imperfect

ADDRESS OF THE CHAIRMAN

DELIVERED AT THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES, INDIA, ON FEBRUARY 4, 1939

BY THE HON'BLE SRI SAMPURNANAND, M L A

MINISTER OF EDUCATION, THE UNITED PROVINCES

I do not know if, after asking me to preside over this function, you began to feel sorry for your mistake An active politician, particularly one who has some hand in the administration of a big province like ours, in the abnormal times through which we are passing, is hardly an ideal president for a gathering of Scientists, who are supposed to have their abode in a serene world, which is not subject to the doubts and uncertainties and passions which constitute the world of the ordinary man You are worshippers of Truth, the pure Truth, and your regions are peopled with those eternal verities of which the philosopher speaks so yearningly

But what after all is this Truth? There was a time when the Theologian claimed to know it and all about it He claimed to have received knowledge of it through direct revelation This claim was contested by Science as the field of scientific research widened Growing in power, acquiring self-confidence with every advance in knowledge, Science finally rejected the claim of Theology and Religion to know and expound the Truth and set up new gods of its own in the temples from which the old images had been dethroned

It was a brilliant pantheon There was the great Atom whose dignity was, if anything, enhanced by the discovery that it was a miniature Solar System composed of protons and electrons, there was that mysterious, all-embracing, jelly, the ether, there was the great law of gravitation which held together the whole universe from the most distance of the receding nebulæ to the proverbial Newtonian apple, there were the laws of the conservation of mass and energy, Space and Time were there, obeying the laws of Arithmetic and Euclidean Geometry True, there were also those two disturbing factors life and mind. The transition from crystal to protoplasm and from protoplasm to consciousness was not easy to describe it is difficult to understand, how extra-mental vibrations transform themselves into thoughts and feelings which, notwithstanding all that the advocates of Behaviourism have been telling us, cannot be completely explained away But in spite of the uncertainties caused by these factors, Science had supreme confidence in itself and its methods it seemed to have reached the solid bedrock of Reality and the exploration of what was still obscure was but a question of time

But this self-complacency has now vanished Science is no longer sure of its foundations The quantum hypothesis and its logical implications seem to indicate the existence of something which is allied almost to free will in the behaviour of atomic constituents and, consequently, defies prediction, Euclidean Geometry is found to be but a logical structure based on axioms and postulates which have no necessary objective validity, in spite, Sir Shah Sulaiman, of your valiant championship, Newtonian physics seems to have all but abdicated in favour of Relativity, the ether has been relegated to the region of myths and we are assured that we are the denizens of an expanding universe which is at once limitless and finite Space, time and the relation, if any, between the two forces, matter, energy—it is difficult to say at the present day what these terms stand for, where all was rhythm and Law, the Principle of Indeterminacy is a recognized and orthodox doctrine, in so far as such a thing can be called a doctrine The other sciences have landed themselves in no less surprising positions and their main problems are as far from solution as ever The researches of Freud, Jung, Adler and the other psycho-analysts have enabled us to probe deep into the working of the human mind and comparative psychology and child-study have been no less helpful, the researches of Jagdish Bose have shown us the striking similarities in the response to stimuli of inanimate and animate matters but life and consciousness remain as much elusive mysteries as they were before

The effect of all this on the scientific mind, on the general outlook of scientific man—a subject on which you are really more competent to speak than I—has been remarkable The attitude of smug self-sufficiency, the superiority-complex born of a false assumption of omniscience, the sense of sneering contempt for religion and the summary dismissal of all extra-scientific attempts to arrive at the Truth, have gone never, I hope, to return The words of the poet are coming to be increasingly realized

"Let knowledge grow from more to more,
But more of reverence in us dwell"

I try to keep myself abreast of modern researches and tendencies in Science difficult as the task is, and I have been a humble student of certain other branches of study as well It gives me joy to see the gulf between Science and Metaphysics being bridged and I hope you will excuse me if I say, without going into the reasons for my statement, with all the force of conviction of which I am capable, that if scientific men would turn to some of the methods of the mystic, the methods of Patanjali, they would see light where today it is all groping in the dark After all, Science has progressed not only through mechanical experimentation but because men of science have had brilliant imaginations, unaccountable intuitive visions of the Truth, flashes of genius which cannot be explained, over-mastering capacity of concentration, and they would be false to themselves and their mission if they refuse to make use of instruments and methods which are reputed to sharpen and make more precise these powers of the human mind You, in your own way, are on the quest of that which is the substratum of all that we see, you, in your own way, have come to the conclusion that the world of nature from the mightiest of Suns to the electron, from the man to the amœba, is subjective, in a very real sense Does not that great wizard of modern Astronomy, Sir James Jeans, posit that the Universe cannot but be pure thought in the mind of a master mathematician, whom you may call God or not, as you choose? Does not Eddington observe —

> "Leaving out all æsthetic, ethical or spiritual aspects of our environment, we are faced with qualities such as massiveness, substantiality, extension, duration, which are supposed to belong to the domain of physics In a sense they do belong, but physics is *not in a position to handle them* directly The essence of their nature is inscrutable, we may use mental pictures to aid calculations, but no image in the mind can be a replica of that which is not in the mind And so, in its actual procedure, physics studies not these inscrutable qualities, but pointer-readings which we can observe. The readings, it is true, reflect the fluctuations of the world-qualities but our exact knowledge is of the readings, not of the qualities The former have as much resemblance to the latter as a telephone number has to a subscriber"

Or, as he observed in another place —

> "The stuff of the world is mind-stuff The mind-stuff is not spread in space and time, these are part of the cyclic scheme ultimately derived out of it."

Is this very different from what the philosopher says when he speaks of the universe as a मनोराज्य? About that which lies beyond and behind all this, the Vedanti says यस्मिन् ज्ञाते सर्वमिदम् ज्ञात भवति, "that, which being known, all this becomes known." Again, when speaking of the impassable gulf which seems to separate matter from mind, have you cared to study Kapila's system, in which both have been derived from प्रधान? I will not tire you out with such references but I am convinced that study of this kind will do inestimable good to both Science and philosophy

This is one of the spheres in which Science has had to cry halt There is another sphere in which, I hope, there is considerable searching of heart among scientific men Apart from its great function of satisfying human curiosity giving us intellectual and æsthetic satisfaction, Science has the more practical responsibility of satisfying certain human needs. If the amenities of life today are greater than they ever were before, if there is greater control over disease and death, if humanity is more like a family than at any other period in its history, the credit for all this must go to Science But equally to Science must go the discredit for all the mutilation, incendiarism, the painful death and insane destruction of innocent life and property, that make modern warfare so hideous The sins of imperialism and capitalism are great but the sins of Science, which has made all this possible, are greater Knowledge is good in itself and it is a powerful instrument for good but it is an equally powerful instrument for evil Everyone is not fit to wield this power that is why in our country it was laid down that knowledge is to be imparted only to those who are सपात्र, fit vehicles for it. And, in any case, the man of Science should not prostitute his genius before the wielders of temporal or financial power He, as the Brahman of today, should realise the dignity of his position and it should be part of his vocation to raise not only the standard of knowledge or comfort of humanity but to raise the level of its spiritual sense as well It is not enough to cater to the demands of man, as we find him, today, it is also necessary to decide what kind of man we want to inhabit this earth So far, Science has neglected this duty, with the result that life has today become a hideous nightmare Science will neglect this duty further at its peril its will be the responsibility for the inevitable collapse of civilization and all that man holds beautiful and sacred

Coming now to some of the specific problems nearer home, there can be no two opinions about the place of Science in the life of the India of today and tomorrow We are on the threshold of great changes. Our country is very soon going to take its place in the comity of free nations We have vast resources, on the surface and below it, of which we are not even aware, even those that are known are insufficiently tapped Again, it is forgotten that these forest and mineral resources are assets which should be exploited, for the good, not of individuals or corporations whose sole aim is to make a profit, but of the community, of the nation, certainly, and of humanity as a whole, if mankind is ever better organized Much of this wealth cannot be reproduced and must be conserved. There are vast areas which are lying barren they could be covered with smiling vegetation There are diseases which find our climatic and socio-economic conditions peculiarly favourable they have to be combated, so have famine and flood and early death. The vitality of the people has to be raised, healthier and less fatiguing methods of work have to be devised and their earning capacity and incomes augmented For help in organizing all this, we look to the Scientist. He should be the guide, philosopher and friend of the people and of those who administer the affairs of the people in their name and on their behalf Inspired by a genuine love of Truth and a desire to serve humanity, he should work as the Brahman of old did, not for name or the love of money Party factions have no meaning for him Above all, the Indian Scientist has to remember that it is his privilege to help in the regeneration of a country with noble traditions of scholarship and public service, but, withal, a country which, today, is among the poorest of the poor and cannot give adequate recompense or recognition to scholarship and research Cramped as we are, we have great minds of which any country may well be proud Bose and Raman are names to conjure with, in the world of Science Our own laboratories have been the scenes of memorable researches and the work of Meghnad Saha, Birbal Sahni, Nil Ratan Dhar and Bholanath Singh has met with appreciation beyond our frontiers This is but natural. This province has been the seat of great centres of learning from time immemorial and is, I have no doubt, destined to make still greater contributions to human knowledge

The existence in our midst of an association like yours should prove a great incentive to scientific research and provide that common meeting ground where all those who are engaged in such work can come together, compare notes and make plans for co-ordinated effort for the future It should be possible to have greater co-operation than exists today between you on the one hand and the Government, industrialists and educational authorities on the other I wish you a very prosperous career of public service and hope that your deliberations in this session will prove of value to the realm both of pure and applied Science

VOTE OF THANKS

To the Hon'ble Sri Sampurnanand, M L A, Chairman of the Eighth Annual Meeting of the National Academy of Sciences, India, held on February 4, 1939

By A C Banerji, M A, M Sc, I E S and K N Bahl, D Phil., D Sc

Proposing a vote of thanks to the Hon'ble Sri Sampurnanand, on behalf of the National Academy of Sciences, for accepting the invitation to preside over the annual function, Prof A C Banerji said —

He thanked the Hon'ble Minister for very kindly accepting the invitation to preside over the annual meeting and he hoped that the Hon'ble Minister would continue to take keen interest in the welfare of the Academy

Seconding the vote of thanks Prof K N Bahl said —

I have great pleasure in seconding the vote of thanks to the Hon'ble Minister proposed by my friend Professor A C Banerji Extremely busy as the Hon'ble Minister is, it is very good of him to have come down to Allahabad to attend our annual meeting and to speak to us He has given us a critical appreciation of the benefits of scientific research but he has also spoken of the weapons of destruction invented by men of science I am not sure if the scientists alone are to blame, for I have no doubt that the blame for destruction must be shared to a large extent by the active politicians who make use of the scientific workers for their own political purposes

I once more thank the Hon'ble Minister for his kindness, and I am sure you will join me in according him our best thanks

Vote of Thanks

To the Retiring Office Bearers of the National Academy of Sciences, India

By Saligram Bhargava, M Sc, and S Dutt, D Sc, P R S

Proposing a vote of thanks to the retiring office-bearers of the National Academy of Sciences, India, Prof Saligram Bhargava said as follows at the annual meeting of the Academy held on February 4, 1939 —

Sir,

I rise to move a vote of thanks to the retiring officers of the Academy Out of these Professor Sahni has retired but others, Dr Bhattacharya, Dr. Mehra, Dr Sane and Dr Pearey Lal, have changed their offices. Thus their experience and advice will still be available to the Academy Some of them had to retire having been in their offices for a full term of four years. According to the rules they could not continue longer It is hoped that they will contribute as much to the progress of academy in their new offices to which they have been elected

Seconding the vote of thanks Dr S Dutt said —

I have much pleasure in seconding the vote of thanks proposed by Prof Saligram Bhargava to the retiring office-bearers The retiring office-bearers have very successfully guided the destinies of the Academy during the past several years, and, although they are retiring, I have every hope that their experience and advice will be available to their successors

APPENDIX 1

ABSTRACT OF THE PROCEEDINGS

The Council resolved that Prof N R. Dhar and Dr S Dutt be nominated to the Council of the National Institute of Sciences of India for the year 1938 as Additional Vice-President and Additional Member respectively on behalf of the National Academy of Sciences, India.

The Academy passed the following resolutions —

That the Government of the United Provinces is requested to appoint a committee consisting of eminent lawyers, scientific experts and representatives of industry to study the present electricity act and to recommend necessary legislation required to nationalise the generation and distribution of electricity with a view to make the supply of electrical power in this province cheap and abundant.

That the Government is requested to select a body of graduates in physics and electrical engineering to study the methods of construction of power-station and the organisation of generation and distribution of electrical energy in foreign countries like England, Russia and Switzerland It is desirable that the body should consist of an expert and experienced electrical engineer who will be in charge of a batch of four students to study the different aspects of the question, *i e*, two for studying constructional details, one for studying the methods of distribution of electricity, and one for studying the economics of production and distribution

That the Government is requested to appoint a permanent body to study the natural resources of power existing within or in the neighbourhood of the province The person in charge of the above-said body should be a competent electrical engineer with experience and knowledge of the different branches of Science, *viz.*, physics, fuel-engineering, hydro-electric engineering, which are required for such kind of survey work

The National Academy of Sciences notes with regret that the Government of the United Provinces, while appointing an Electricity Committee, did not consider it necessary to ask this Academy to nominate a specialist to serve on the said Committee and requests the Government to consider the advisability of associating representative or representatives of this Academy with all those investigations in which scientists can make useful contributions

The Council accepted with great regret the resignation of Prof B. Sahni from the Presidentship of the Academy and placed on record its deep appreciation of the services rendered by him to the National Academy of Sciences, India

It was unanimously resolved that the Hon'ble Sir Shah Muhammad Sulaiman, Kt., M A , LL D., D Sc , Judge, Federal Court of India, and Vice-Chancellor, Muslim University, Aligarh, be elected President of the National Academy of Sciences, India, for the residue of the term of Prof B Sahni

It was decided to bring out a booklet on the Problems of Power Supply in India.

It was resolved that Prof Saligram Bhargava and Dr S Dutt be nominated editors in the places of Prof M N Saha and Prof N R. Dhar

The following members were elected Fellows of the Academy in the Fellows' Meeting held on November 29, 1938 —

1 Ram Behari, M A , Ph D , Reader in Mathematics, University of Delhi, Delhi

2 Saradindu Basu, M Sc , Meteorologist, Upper Air Observatory, Agra

The following members were nominated delegates to represent the Academy at the meetings of the Indian Science Congress held at Lahore in January, 1939 —

1 Sir Shah Muhammad Sulaiman, Kt., M A , LL D , D.Sc., Judge, Federal Court of India, New Delhi

2 A C Banerji, M A , M.Sc., F.R.A S , F N I , I E S , Professor of Mathematics, Allahabad University, Allahabad

3 J H. Mitter, M.Sc , Ph D , Professor of Botany, Allahabad University, Allahabad.

4 H. R. Mehra, M Sc , Ph D , F N I , Reader in Zoology, Allahabad University, Allahabad

5 D S Kothari, M Sc , Ph D., F N I , Reader in Physics, University of Delhi, Delhi.

It was resolved that His Exalted Highness the Nizam of Hyderabad (Deccan) and the Hon'ble Sir Shah Muhammad Sulaiman, Kt., M.A , LL D., D Sc., Judge, Federal Court of India, New Delhi, be elected Benefactors of the National Academy of Sciences, India

The following members were elected Office-bearers and Members of the Council of the National Academy of Sciences, India, for the year 1939 —

PRESIDENT

The Hon'ble Sir Shah Muhammad Sulaiman, Kt , M A., LL D , D Sc , F N I

VICE-PRESIDENTS

H R. Mehra, M Sc , Ph D., F N I
S. M Sane, B.Sc , Ph D

HONY TREASURER

Saligram Bhargava, M Sc.

General Secretaries

Shri Ranjan, M.Sc (Cantab), D Sc., F A Sc
D S Kothari, M Sc , Ph D , F N I

Foreign Secretary

D R Bhattacharya, D Sc , Ph D., F.Z S., F N I

Members of the Council

S B Dutt, D Sc , P R.S , F N I
M R. Siddiqui, M A , Ph D , F N I
A C Banerji, M A , M Sc , F R A S , I E S , F N I
P L Srivastava, M A , D Phil (Oxon), F N I
Rao Bahadur B Viswanath, F I C , F N I
M N Saha, D Sc., F R.S , F N I
K N Bahl, D Sc , D Phil , F N I
J C Ghosh, D Sc , F N I
A M Kureishy, M A

APPENDIX 2

OFFICE-BEARERS AND MEMBERS OF THE COUNCIL OF THE NATIONAL ACADEMY OF SCIENCES, INDIA, FOR THE YEAR 1938

PRESIDENT

B Sahni, D Sc , Sc D , F R.S , F N I (*Resigned Presidentship on April 29, 1938*)

The Hon'ble Sir Shah Muhammad Sulaiman, Kt., M A , LL D , D Sc , F N I (*Elected President on July 17, 1938*)

VICE-PRESIDENTS

D R. Bhattacharya, D Sc , Ph D , F Z S , F N I
The Hon'ble Sir Shah Muhammad Sulaiman, Kt , M A , LL D , D Sc , F N I
(*One Vice-Presidentship remained vacant from July 17, 1938*)

HONY TREASURER

H. R. Mehra, M.Sc , Ph D , F N I

GENERAL SECRETARIES

S M Sane, B Sc , Ph D
P L Srivastava, M A , D Phil (Oxon), F N I

FOREIGN SECRETARY

M N Saha, D Sc , F R.S , F N I

MEMBERS OF THE COUNCIL

S B Dutt, D Sc , P R.S., F N I
N R Dhar, D Sc., F I C , I E S , F N I
J A Strang, M.A., B Sc.
K N Bahl, D Sc., D Phil , F N I
Shri Ranjan, D Sc
J C Ghosh, D Sc., F N I
A C Banerji, M A., M Sc., F R.A S , I E S , F N I
Sam Higginbottom, Ph D
S K. Banerji, D Sc., F N.I

APPENDIX 3

List of Members

(*Arranged alphabetically*)

*—Denotes a Fellow

†—Denotes a Fellow of the National Institute of Sciences of India

Date of Election		Alphabetical List of Members
31-10-35		Agarwal, Rai Amar Nath, Bari Kothi, Daraganj, Allahabad
20-4-36	*	Ahmad, Ziauddin, D Sc, Vice-Chancellor, Muslim University, Aligarh.
20-4-35	† *	Ajrekar, Shripad Lakshman, B A, I E.S, 855 Bhamburda, Poona.
17-4-31	*	Asundi, R K., Ph D, Reader, Physics Department, Muslim University, Aligarh
10-5-35	† *	Ayyangar, G N Rangaswami, Rao Bahadur, B A, I A S., Millets Specialist to the Government of Madras, Agricultural Research Institute, P O Lawley Road, Coimbatore
1-1-30	† *	Bahl, K N, D Phil., D Sc, Professor of Zoology, Lucknow University, Lucknow
1-1-30	† *	Banerji, A C, M.A., M.Sc, F R.A S., I E.S, Professor of Mathematics, Allahabad University, Allahabad
22-12-32	† *	Banerji, S K., D Sc., Meteorologist, Ganeshkhind Road, Poona 5
10-5-37		Bari, Abdul, M Sc, Lecturer in Botany, Osmania University, Hyderabad, Deccan
20-4-36	*	Basu, N M., D Sc, 7 Bakshi Bazar Lane, Dacca.
17-4-31	*	Basu, Saradindu, M.Sc., Meteorologist, Ganeshkhind Road, Poona 5
31-10-35	† *	Bharadwaja, Yajnavalkya, Ph D, Professor of Botany, Hindu University, Benares
19-3-31	*	Bhargava, Saligram, M.Sc., Reader, Physics Department, Allahabad University, Allahabad
17-4-31		Bhargava, Vashishta, M Sc., I C S., Sessions and Subordinate Judge, Agra.
17-4-31		Bhatia, K B., I C S., Finance Department, U P. Secretariat, Lucknow
17-12-35		Bhatia, M. L., M Sc., Lecturer in Zoology, Lucknow University, Lucknow
15-9-36		Bhatnagar, Birendra Kumar, B Sc., Bank Road, Allahabad

Date of Election		Alphabetical List of Members
21-4-33	† *	Bhatnagar, S. S., D Sc., O B E., Professor of Chemistry, Government College, Lahore
20-12-34		Bhattacharya, A K., D Sc., Chemistry Department, Allahabad University, Allahabad
17-4-31		Bhattacharya, D P, M Sc., Bareilly College, Bareilly
1-1-31	† *	Bhattacharya, D R., M.Sc., Ph D, Docteur ès Sciences, Professor of Zoology, Allahabad University, Allahabad
20-4-36	*	Bose, N K, Ph D, Mathematical Officer, Irrigation Research Institute, Lahore
20-4-36	† *	Burridge, W., D M, M A. (Oxon), Professor of Physiology, Lucknow University, Lucknow
31-10-35		Chakravarty, D N, D Sc., Professor of Chemistry, College of Science, Nagpur
10-5-35	† *	Champion, H G, M A, Sylviculturist, Imperial Forest Research Institute, Dehra Dun
1-1-30	† *	Chatterji, G, M Sc, Meteorologist, Upper Air Observatory, Agra
17-4-31	*	Chatterji, K. P, M.Sc, A I C., F C S, Reader, Chemistry Department, Allahabad University, Allahabad
10-5-37		Chatterji, N G, D Sc., H B, Technological Institute, Cawnpore
9-2-34		Chaturvedi, Pandit Champa Ram, Professor of Mathematics, St. John's College, Agra.
17-12-35		Chaudhury, K, Ahmad, M.Sc, Wood Technologist, Imperial Forest Research Institute, Dehra Dun
10-5-37		Chaudhury, S S, M.A., M.Sc, Kadam Kuan, P O Bankipore, Patna
10-5-35	† *	Chopra, R N, Lt-Col, C I E., M B, I M S, Director, School of Tropical Medicine, Central Avenue, Calcutta.
31-10-35		Dabadghao, V M., Physics Department, College of Science, Nagpore
28-10-32	*	Das, A. K, D Sc, Upper Air Observatory, Agra
22-12-32	*	Das, B K., D Sc., Professor of Zoology, Osmania University, Hyderabad, Deccan
19-8-31	*	Das, Ramsaran, D Sc., Zoology Department, Allahabad University, Allahabad
17-12-35	*	Das Gupta, S N, M.Sc., D I.C, Ph D., Reader in Botany, Lucknow University, Lucknow
29-7-36		Dass, A T., Dharam, M Sc, 13 Strachey Road, Allahabad
20-4-36	† *	Datta, S., D Sc., D I C., Professor of Physics, Presidency College, Calcutta.

Date of Election		Alphabetical List of Members
15-9-37		Dayal, Jagadeshwari, M.Sc., Zoology Department, Lucknow University, Lucknow
17-4-31	*	Deodhar, D B., Ph D., Reader, Physics Department, Lucknow University, Lucknow
31-10-35		Desai, M. S, M.Sc., Professor of Physics, M.T B College, Surat.
29-2-32		Deb, Suresh Chandra, D Sc, Research Physicist, Bose Institute, Calcutta.
17-4-31	*	Dey, P K, M Sc., I A.S, Plant Pathologist to Government, United Provinces, Nawabganj, Cawnpore.
1-1-30	† *	Dhar, N R., D Sc, Docteur ès Sciences, F I C, I E.S, Deputy Director of Public Instruction, U P, Allahabad
31-10-35		Dube, Ganesh Prasad, M Sc., Lecturer in Physics, Balwant Rajput College, Agra.
23-4-37		Dubey, V S, M Sc., Ph D, D I.C, Professor of Economic Geology, Hindu University, Benares
28-10-32		Dutt, A K, D Sc., Research Physicist, Bose Research Institute, Calcutta
17-4-31	† *	Dutt, S B, D.Sc., Reader, Chemistry Department, Allahabad University, Allahabad
19-3-31		Dutt, S K, M Sc, Zoology Department, Allahabad University, Allahabad
1-2-37		Gandhy, Darabshaw J, Esq, Agricultural Engineering Deptt., U P., Cawnpore
20-4-36		Ganguly, P B., D Sc, Professor of Chemistry, Science College, Bankipore P O, Patna.
22-2-33		Ghatak, Narendranath, M Sc. D Sc, Chemical Assistant, Indian Stores Department, Government Test House, Alipore, Calcutta.
20-4-36	† *	Ghosh, J., M.A, Ph D, Professor of Mathematics, Presidency College, Calcutta.
8-11-33	† *	Ghosh, J C, D Sc., Professor of Chemistry, Dacca University, Dacca.
19-3-31	*	Ghosh, R. N, D Sc., Physics Department, Allahabad University, Allahabad
19-3-31	*	Ghosh, Satyeshwar, D Sc., Chemistry Department, Allahabad University, Allahabad.
20-4-36	† *	Ghosh, S L., Ph.D., Professor of Botany, Government College, Lahore
17-4-31	*	Gupta, B. M, Ph D., Deputy Public Analyst to Government, United Provinces, Lucknow

Date of Election		Alphabetical List of Members
10-5-37		Gupta, K M, M Sc, D Sc, Professor of Biology, M T B. College, Surat.
17-4-31		Higginbottom, Sam, D Phil, Principal, Allahabad Agricultural Institute, Naini, E I R, Allahabad
10-5-37	†	Husain, M. Afzal, Khan Bahadur, M A, M Sc, I A S, Vice-Chancellor, Punjab University, Lahore
21-12-36		Husain, Zahur, B A (Hons), c/o Prof A K Nyazee, M A, Superintendent, The 'Quadrangle' Hostel, Government College, Lahore
10-5-37		Ishaq, Mohammad, Ph D, Physics Deptt, Muslim University, Aligarh, U P
20-4-36	*	John, C C, Professor of Zoology, Agra College, Agra.
3-4-34		Joshi, A D, P E.S, Lecturer, Training College, Lucknow
10-5-37		Kalapesi, A S, B.A, B Sc, D I C., Ph D, F R.G S, Professor, St. Xavier's College, Cruickshank Road, Fort, Bombay
10-5-37		Khan, A S, M Sc, D D P I, Bihar, 7 Strand Road, Patna.
15-9-31	† *	Kichlu, P K, D Sc, Department of Physics, Government College, Lahore
21-4-33		Kishen, Jai, M.Sc., Professor of Physics, S D College, Lahore
9-2-34	† *	Kothari, D S, M.Sc, Ph D, Professor of Physics, Delhi University, Delhi.
3-4-34	† *	Krishna, Shri, Ph.D, D Sc., F I C., Forest Biochemist, Imperial Forest Research Institute, Dehra Dun
5-10-33		Kureishy, A M, M A, Reader in Mathematics, Muslim University, Aligarh
31-10-35		Lal, Rajendra Bihari, M.Sc, Assistant Traffic Superintendent, E.I R., c/o Babu Basant Behari Lall, B A, Partabgarh City (Oudh)
10-5-37		Mahabale, T S, B A, M Sc, Deptt. of Biology, Gujarat College, Ahmedabad
1-1-30	† *	MacMahon, P S, B Sc. (Hons), M Sc, Professor of Chemistry, Lucknow University, Lucknow
15-9-37		Mahadevan, C., M A, D Sc, Assistant Superintendent, Hyderabad Geological Survey, Hyderabad (Deccan)
31-10-35	† *	Maheshwari, Panchanan, D Sc., Botany Department, Allahabad University, Allahabad.
31-10-35		Majumdar, R. C, M.Sc., Ph D, Bose Research Institute, 93 Upper Circular Road, Calcutta.

Date of Election		Alphabetical List of Members
10-5-37		Mathur, A P., M.Sc., D I C, D Sc., Principal, Darbar Intermediate College, Rewa, C I
31-10-35	*	Mathur, K. N, D Sc., Lecturer in Physics, Lucknow University, Lucknow
31-10-35		Mathur, Lakshmi Sahay, M.Sc., Upper Air Observatory, Agra.
8-11-33	*	Mathur, Ram Behari, M.Sc., Professor of Mathematics, St. Stephenson College, Delhi
17-12-35	† *	Matthai, George, M A, Sc D, F.R S E., I E.S, Professor of Zoology, Punjab University, Lahore
19-3-31		Mazumdar, Kanakendu, D Sc, Physics Department, Allahabad University, Allahabad
1-1-30	† *	Mehta, K C, Ph D, M Sc., Agra College, Agra.
19-3-31	† *	Mehra, H R., Ph D, Reader, Zoology, Department, Allahabad University, Allahabad
1-1-30	*	Mitter, J H, M Sc, Ph D, Professor of Botany, Allahabad University, Allahabad.
23-4-37	*	Misra, Avadh Behari, D.Sc., D Phil, Deptt. of Zoology, Benares Hindu University, Benares.
31-10-35		Mohan, Ananda, B Sc., Assistant Traffic Superintendent, E I.R., Chief Commercial Manager's Office, 105 Clive Street, Calcutta.
10-5-37		Moudgill, K. L., Principal, H H Maharaja's College of Science, Trivendrum (Travancore State)
20-4-35	† *	Mowdawalla, F N, M A, M I E E, Mem A I E E, M.I E, 301, Frere Road, Fort, Bombay
1-1-30	*	Narayan, Luxmi, D Sc, Reader, Mathematics Department, Lucknow University, Lucknow
22-2-33	*	Narliker, V V., M.A., Professor of Mathematics, Benares Hindu University, Benares
23-4-37	*	Nath, Raj, D I C., Ph D., Deptt. of Geology, Benares Hindu University, Benares
20-4-35	† *	Normand, C W B, M A, D Sc., Director General of Observatories, Poona.
31-10-35		Oak, V G., M Sc, I C S, Additional District Judge, Meerut.
16-8-35		Pande, Kedar Dat, M Sc., Lecturer, Training College, Agra
17-4-31	*	Pandya, K. C., Ph D., St. Jonh's College, Agra.
3-4-33	† *	Parija, P K., M A, I E S, Ravenshaw College, Cuttack
10-5-35	† *	Pinfold, Ernest Sheppard, M.A., F G S., Geologist, Attock Oil Co., Ltd, Rawalpindi.

Date of Election		Alphabetical List of Members
18-9-35	*	**Pramanik**, S. K., M.Sc., Ph D, D I C, Meteorologist, Meteorological Office, Poona 5
3-4-33	† *	**Prasad**, Badri Nath, Ph D., Docteur ès Sciences, Mathematics Department, Allahabad University, Allahabad
5-10-33	*	**Prasad**, Gorakh, D Sc., Reader in Mathematics, Allahabad University, Allahabad
21-4-33	*	**Prasad**, Kamta, M A, M Sc, Professor of Physics, Science College, P O Bankipore (Patna)
15-9-31	† *	**Prasad**, Mata, D Sc, Royal Institute of Science, Bombay
10-5-37		**Prasad**, Shiva Parbati, M A (Cantab), Professor of Physics, Science College, Patna
10-5-37		**Rahimullah**, M, M.Sc., Lecturer in Zoology, Osmania University, Hyderabad
10-5-37		**Rahman**, Wahidur, B Sc (Cal), Professor of Physics, Osmania University, Hyderabad, Deccan
20-12-34		**Rai**, Ram Niwas, M Sc., Physics Department, Allahabad University, Allahabad
15-9-37		**Raina**, Shyam Lal, M Sc., Professor of Biology, S P College, Srinagar, Kashmir
10-5-37		**Ramiah**, K, Geneticist and Botanist, Institute of Plant Industry, Indore
3-4-33	*	**Ram**, Raja, M.A, B E., Professor of Civil Engineering, Thompson College, Roorkee
23-4-37		**Randhawa**, M S., I C S, Assistant Commissioner, Fyzabad
19-3-31	*	**Ranjan**, Shri, M.Sc (Cantab), Docteur ès Sciences, Reader, Botany Department, Allahabad University, Allahabad
15-9-31	*	**Rao**, A Subba, D Sc, Department of Zoology, Central College, Bangalore
22-2-33		**Rao**, G Gopala, B.A., M.Sc., D Sc, Chemistry Department, Andhra University, Waltair
20-4-35	*	**Rao**, L, Rama Krishna, M.A, Ph D, D Sc, Department of Physics, Andhra University, Waltair
14-3-34	† *	**Rao**, K., Rangadharma, D Sc, Physics Department, Andhra University, Waltair
22-2-33	† *	**Ray**, Bidhubhusan, D Sc, 92 Upper Circular Road, Calcutta
1-2-36		**Ray**, J P, M Sc, Professor, D A V College, Dehra Dun
10-5-37		**Ray**, Ramesh Chandra, D Sc., F I C, Professor of Chemistry, Science College, Patna.

Date of Election		Alphabetical List of Members
21-12-31		Ray, Satyendra Nath, M.Sc, Physics Department, Lucknow University, Lucknow
23-4-37		Rode, K P, M.Sc, Asst. Professor of Geology, Benares Hindu University, Benares
29-2-32		Saha, Jogendra Mohan, M Sc., Manager, Sitalpur Sugar Works, P O Dighwara, Dist Saran
1-1-30	† *	Saha, M.N, D Sc., F R S, F A.S B., F Inst. P., P R.S, Palit Professor of Physics, University College of Science, 92, Upper Circular Road, Calcutta
1-1-30	† *	Sahni, B, D Sc, Sc D, F.R.S, Professor of Botany, Lucknow University, Lucknow
17-4-31	*	Sane, S M, B Sc, Ph D, Reader, Chemistry Department, Lucknow University, Badshah Bagh, Lucknow
1-2-36	*	Saxena, Ram Kumar, D Sc, Lecturer in Botany, Allahabad University, Allahabad
2-3-37		Schroff, M.L, B A, M.S (Mass), Head of the Department of Pharmaceutical Chemistry, Benares Hindu University, Benares
10-5-37		Sayeeduddin, M, M A, B.Sc, Professor of Botany, Osmania University, Hyderabad, Deccan
31-10-35	† *	Sen, Jitendra Mohan, M Ed, B Sc., Teacher's Dip, F R.G.S, D Ed, Principal, Krishnagar College, Krishnagar
3-4-33	*	Sen, K C, D Sc, Officer-in-charge, Animal Nutrition Section, Imperial Veterinary Research Institute, Izatnagar, U P
20-4-35	† *	Sen, Nikhil Ranjan, D Sc., Professor of Mathematics, 92 Upper Circular Road, Calcutta
17-12-35	† *	Sen Gupta, N N, Ph D, Professor of Psychology, Lucknow University, Lucknow
20-12-34	*	Sen Gupta, P K, D Sc, Weather Section, Indian Meteorological Department, Bhamburda, Poona 5
10-5-37		Seth, Trilok Nath, M Sc, Ph.D, Lecturer and Head of the Department of Medical Chemistry, Medical College, Patna
19-3-31	*	Sethi, Nihal Karan, D Sc, Agra College, Agra
23-4-37		Sethi, D R, Esq, I.A.S., Director of Agriculture, Bihar, Patna
31-10-35		Shabde, N G, D Sc, Professor of Mathematics, College of Science, Nagpur
10-5-37		Sharma, Dhyan Swarup, B Sc, 40, Kaiserbagh, Lucknow
31-10-35		Sharma, P N, M Sc., Physics Department, Lucknow University, Lucknow

Date of Election		Alphabetical List of Members
15-9-31		Sharma, Ram Kishore, M Sc, Physics Department, Ewing Christian College, Allahabad
18-9-35		Shukla, Janardan Prasad, M Sc, Indian Institute of Sugar Technology, Cawnpore
3-4-33	† *	Siddiqi, M.R., Ph D, Professor of Mathematics, Osmania University, Hyderabad, Deccan
3-4-33	*	Siddiqui, Mohammad Abdul Hamid, M A, M S, F R C S, D L O, Professor of Anatomy, King George's Medical College, Lucknow
10-5-37	†	Singh, Bawa Kartar, M A (Cantab), Sc D, F I C, I E S, Professor of Chemistry, Science College, Patna, and Chemical Adviser to the Department of Industries, Bihar
17-12-35	*	Singh, Bhola Nath, D Sc, Kapurthala Professor of Agricultural Botany and Plant Physiology, Head of the Institute of Agricultural Research, Hindu University, Benares.
10-5-37		Singh, T C N, D Sc, Asst Economic Botanist, In-charge Botanical Section, Sabour (Bihar)
17-4-31		Soonawala, M F, M Sc, Maharaja's College, Jaipur (Rajputana)
18-9-35		Srivastava, Bishwambhar Nath, M Sc, Lecturer, Physics Department, Allahabad University, Allahabad
19-3-31	† *	Srivastava, P L, M A, D Phil, Reader, Mathematics Department, Allahabad University, Allahabad
10-8-33	*	Srivastava, R C, B Sc (Tech), Sugar Technologist, Imperial Council of Agricultural Research, India, Cawnpore
15-9-31	*	Srikantia, C, B A, D Sc, Medical College, Mysore
19-12-32	*	Strang, J. A, M A, B Sc, Professor of Mathematics, Lucknow University, Lucknow
17-4-31	† *	Sulaiman, S M., Hon'ble Sir, Kt., M A, LL D, D Sc, Judge, Federal Court of India, Delhi.
20-4-36	*	Sur, N K., D Sc, Meteorologist, Meteorological Department, Poona
17-12-35		Tandon, Amar Nath, M Sc., D Phil, Physics Department, Allahabad University, Allahabad
9-11-35		Tandon, Prem Narain, M.Sc., I C S, Joint Magistrate, Gaya, Bihar
15-9-37		Thapur, G S., Ph.D, Reader in Zoology, Lucknow University, Lucknow
23-4-37		Tiwari, N K., M Sc (Alld), Asst. Professor of Botany, Hindu University, Benares

Date of Election		Alphabetical List of Members
19-3-31	*	Toshniwal, G R, M.Sc, D Sc., Physics Department, Allahabad University, Allahabad
15-9-36		Trivedi, Hrishikesh, M Sc., D Sc., Physical Assistant, Government Test House, Judge's Court Road, Alipur (Calcutta)
3-4-34		Varma, Rama Shanker, M Sc, Christ Church College, Cawnpore.
20-12-34		Varma, S C, M Sc, Zoology Department, Allahabad University, Allahabad.
9-2-34		Vaugh, Mason, B Sc (Ing), Agricultural Engineer, Allahabad Agricultural Institute, Naini (E I Ry) (Allahabad)
2-3-37		Vestal, Edgar F., Ph D, Botany Section, Agricultural Institute, Naini, E.I.R.
19-3-31	† *	Vijayaraghavan, T., D Phil., Reader, Mathematics Department, Dacca University, Ramna, Dacca
20-4-35	† *	Vishwanath, B., Rao Bahadur, F I.C, Director, Imperial Agricultural Research Institute, New Delhi.
20-4-35	† *	Wadia, D N, M A, B Sc., F G.S F R.G.S., Geological Survey of India, 27, Chowringhee, Calcutta
1-1-30	† *	Wali, Mohammad, Ch., M.A, Ph D, I.E S, Professor of Physics, Lucknow University, Lucknow

N B —The Secretaries will be highly obliged if the members will kindly bring to their notice errors, if there be any, in their titles, degrees, and addresses

APPENDIX 4

LIST OF EXCHANGE JOURNALS

INDIAN

Publishers	Journals
ALLAHABAD	
Mu Pi Omega Society	Proceedings of the Mu Pi Omega Society
BANGALORE	
The Indian Academy of Sciences	Proceedings of the Indian Academy of Sciences, Section A
"	" Section B
The Indian Institute of Science	Journal of the Indian Institute of Science, Section A
"	" Section B
"	Current Science
Department of Electrical Technology, Indian Institute of Science	Electrotechnics
Society of Biological Chemists, India	Proceedings of the Society of Biological Chemists, India
BOMBAY	
Haffkine Institute	Report of the Haffkine Institute
CALCUTTA	
Asiatic Society of Bengal	Journal of the Asiatic Society of Bengal (Letters)
"	Journal of the Asiatic Society of Bengal (Science)
"	Year Book
"	Journal and Proceedings of the Asiatic Society of Bengal
National Institute of Sciences of India	Transactions of the National Institute of Sciences of India
"	Indian Science Abstracts
"	Proceedings of the National Institute of Sciences of India
"	Report of the Council of the National Institute of Sciences of India
Indian Association for Cultivation of Science	Indian Journal of Physics and Proceedings of the Indian Association for the Cultivation of Science

Publishers	Journals
CALCUTTA	
Bose Research Institute	Transactions of the Bose Research Institute
Indian Science News Association	Science and Culture
Indian Chemical Society	The Journal of the Indian Chemical Society
Oxford University Press	Indian Physico-Mathematical Journal
COONOR	
Nutrition Research Laboratories	Publications of the Laboratories
MADRAS	
Department of Fisheries	Journals, Administration Report
Madras Government Museum	Bulletin of the Madras Government Museum, Natural History Section
NEW DELHI	
Industrial Research Bureau	Bulletin of the Indian Industrial Research
Imperial Council of Agricultural Research	Indian Journal of Agricultural Science
„	Indian Journal of Veterinary Science and Animal Husbandry
„	Scientific Monographs of the Imperial Council of Agricultural Research
„	Agriculture and Livestock in India
NAGPUR	
Nagpur University	Nagpur University Journal
HYDERABAD (DECCAN)	
Osmania University	Journal of the Osmania University
PATNA	
Philosophical Society, Patna Science College	Bulletin of the Patna Science College Philosophical Society
POONA	
Indian Meteorological Department	Scientific Notes
„	Memoirs of the Indian Meteorological Department

FOREIGN

AUSTRALIA

Publishers	Journals
ADELAIDE	
The Royal Society of South Australia	Transactions of the Royal Society of South Australia
EAST MELBOURNE	
Council for Scientific and Industrial Research	Journal of the Council for Scientific and Industrial Research
"	Pamphlet of the Council for Scientific and Industrial Research
"	Annual Report
Radio, Research Board Council for Scientific and Industrial Research	Bulletin of the Radio Research Board
MELBOURNE	
Royal Society of Victoria	Proceedings of the Royal Society of Victoria
SYDNEY	
Royal Society of New South Wales	Journal and Proceedings of the Royal Society of New South Wales

AUSTRIA

Publishers	Journals
VIENNA	
Akademie der Wissenschaften	Anzeiger (Mathematisch-naturwissenschaftliche Klasse)
"	Anzeiger (Philosophisch-historische Klasse)
"	Almanach

BELGIUM

Publishers	Journals
BRUSSELS	
L' Academie Royale de Belgique	Bulletin de la Classe des Sciences
"	Annuaire de l'Academie Royale de Belgique

BRAZIL

Publishers	Journals
RIO DE JANEIRO	
Instituto Oswaldo Cruz	Memorias do Instituto Oswaldo Cruz

Publishers	Journals
CANADA	
OTTAWA	
The Royal Society of Canada	Transactions of the Royal Society of Canada
The National Research Council	Annual Report
TORONTO	
The Royal Astronomical Society of Canada	Journal of the Royal Astronomical Society of Canada
VICTORIA	
The Dominion Astrophysical Observatory	Publications of the Dominion Astrophysical Observatory
CHINA	
NANKING	
National Research Institute of Biology, Academia Sinica	Sinensia
Zoological Society of China, Academia Sinica	Chinese Journal of Zoology
National Research Institute of Chemistry, Academia Sinica	Memoir of the National Research Institute of Chemistry
SHANGHAI	
National Research Institute of Physics, Academia Sinica	Scientific Papers of the National Research Institute of Physics
DENMARK	
COPENHAGEN	
Det Kgl Danske Videnskabernes Selskab	Mathematisk-fysiske Meddelelser
"	Biologiske Meddelelser
L'Académie Royale des Sciences et des Lettres de Denmark	Mémoires de l'académie Royale des Sciences et des Lettres de Denmark
Laboratoire Carlsberg	Comptes-Rendus des Travaux du Laboratoire Carlsberg
EGYPT	
CAIRO	
The Egyptian Medical Association	Journal of the Egyptian Medical Association

ENGLAND

Publishers	Journals
ABERDEEN	
Imperial Bureau of Animal Nutrition	Technical Communications
ABERYSTWYTH	
Imperial Bureau of Plant Genetics Herbage Plants	Bulletins
ST ALBANS, HERTS	
Imperial Bureau of Agricultural Parasitology	Helminthological Abstracts
„	Bibliography of Helminthology
CAMBRIDGE	
Imperial Bureau of Plant Genetics School of Agriculture	Plant Breeding Abstracts
The Philosophical Society	Proceedings of the Cambridge Philosophical Society
EDINBURGH	
The Royal Society of Edinburgh	Proceedings of the Royal Society of Edinburgh
HARPENDEN	
Imperial Bureau of Soil Science, Rothamsted Experimental Station	Technical Communications
„	Reprints
„	Reports
EAST MALLING, KENT	
Imperial Bureau of Fruit Production	Horticultural Abstracts
LONDON	
The Electrician, Bouverie House	Electrician
TEDDINGTON, MIDDLESEX	
The National Physical Laboratory	Reports of the National Physical Laboratory
„	Collected Researches of the National Physical Laboratory

Publishers	Journals
FRANCE	
PARIS	
L'Institute Henri Poincaré	Annales de l'Institute Henri Poincaré
De La Station Biologique de Roscoff	Travaux de la Station Biologique de Roscoff
GERMANY	
BERLIN	
Preussischen Akademie der Wissenschaften	Sitzungsberichte Der Preussischen Akademie
Deutschen Chemischen Gesellschaft	Berichte Der Deutschen Chemischen Gesellschaft
GOTTINGEN	
Gensellschaften Wissenschaften zu Gottingen	Nachrichten von der Gasellschaft der Wissenschaften zu Gottingen Mathematisch-Physikalische Klasse Fachgruppe I Mathematik
„	„ II Physik, Astronomie, Geophysik, Technik
„	„ III Chemie, einschl Physikalische Chemie.
„	„ IV Geologie und Mineralogie
„	„ V Geographie
„	„ VI Biologie
„	Geschaftliche Mitteilungen
HEIDELBERG	
Heidelberger Akademie der Wissenschaften	Sitzungsberichte der Heidelberger Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Klasse
LEIPZIG	
Sachsische Akademie der Wissenschaften	Berichte der Mathematishe Physischen Klasse

Publishers	Journals
LEIPZIG	
Sachsische Akademie der Wissenschaften	Abhandlungen der Mathematisch-Physischen Klasse
MUNCHEN	
Bayerischen Akademie der Wissenschaften zu München	Sitzungsberichte der Mathematisch-naturwissenschaftlichen Abteilung
HOLLAND	
GRONINGEN	
Kapteyn Astronomical Laboratory	Publications of the Kapteyn Astronomical Laboratory
LEIDEN	
Kamerlingh Onnes Laboratory of the University of Leiden	Communications from the Physical Laboratory of the University of Leiden
„	Communications from Kamerlingh Onnes Laboratory
HUNGARY	
BUDAPEST	
Der Ungarischen Akademie der Wissenschaften	Mathematisher und Naturwissenschaftlicher Anzeiger
ITALY	
PALERMO	
Circolo Mathematico di Palermo	Rendiconti del Circolo Mathematico di Palermo
JAPAN	
HIROSHIMA	
Hiroshima University	Journal of Science of the Hiroshima University, Series A
KEIJO	
Medical Faculty, Keijo Imperial University	The Keijo Journal of Medicine

Publishers	Journals
KYOTO	
Physico-chemical Society of Japan, Kyoto Imperial University	Review of Physical Chemistry of Japan
OSAKA	
The Faculty of Science, Osaka Imperial University	Collected Papers from the Faculty of Science
SAPPORO	
The Faculty of Science, Hokkaido Imperial University	Journal of the Faculty of Science, Series I, Mathematics
SENDAI	
Imperial University of Tohoku	Science Reports of the Tohoku Imperial University
TOKYO	
The Imperial Academy	Proceedings of the Imperial Academy
The Institute of Physical and Chemical Research	Scientific Papers
The National Research Council of Japan	Japanese Journal of Mathematics
„	Japanese Journal of Botany
„	Japanese Journal of Physics
„	Japanese Journal of Astronomy and Geophysics
„	Report
„	Report of Radio Research
The Physico-Mathematical Society of Japan	Proceedings of the Physico-Mathematical Society of Japan
MANCHOUKUO	
HSINCHING	
The Institute of Scientific Research	Report of the Institute of Scientific Research
PHILIPPINE ISLANDS	
MANILA	
Bureau of Sciences, Department of Agriculture and Commerce	Philippine Journal of Science

POLAND

Publishers	Journals
CRACOVIE	
Académie Polonaise des Sciences et des Lettres	Comptes Rendus Mensuels des Seances de la classe des Sciences Mathématiques et Naturelles
"	Comptes Rendus Mensuels des Seances de la classe de Medecine
"	Bulletin International, classe des Sciences Mathématiques et Naturelles, Serie A Sciences Mathematiques
"	Bulletin International classe des Sciences Mathematiques et Naturelles, Serie B Sciences Naturelles (I)
"	Bulletin International, classe des Sciences Mathematiques et Naturelles, Serie B Sciences Naturelles (II)
"	Memoires, classe des Sciences Mathematiques et Naturelles, Serie A Sciences Mathématiques
"	Memoirs, classe des Sciences Mathematiques et Naturelles, Serie B Sciences Naturelles
"	Bulletin International, classe de Medecine
"	Memoires classe de Medecine
Polska Akademja Umiejetności	Starunia
WARSAW	
Société des Sciences et des Lettres de Varsovie	Comptes Rendus des Seances, class I (jezykoznawstwa i historji literatury)
"	*Comptes Rendus des Śeances, class II (historycznych, spolecznych i filozoficznych)
"	Comptes Rendus des Seances, class III (matematyczno-fizycznych)
"	Comptes Rendus des Śeances, class IV (bilogicznych)
Polish Physical Society	Acta Physica Polonica

Publishers	Journals
New Zealand	
WELLINGTON	
Royal Society of New Zealand	Transactions and Proceedings of the Royal Society of New Zealand
South Africa	
CAPE TOWN	
Royal Society of South Africa	Transactions of the Royal Society of South Africa
Sweden	
LUND	
Kungl Fysiografiska Sällskapets	Kungl Fysiografiska Sällskapets Forhandlingar
STOCKHOLM	
Kungl Svenska Vetenskapsakademie	Kungl Svenska Vetenskapsakademiens Handlingar
UPPSALA	
Uppsala Universitet	Uppsala Universitets Årsskrift
Switzerland	
GENEVA	
Société de Physique et d' Histoire Naturelle de Genève	Compte Rendu des Séances de La Société de Physique et d' Histoire Naturalle de Genève
Union of Soviet Socialist Republics	
KHARKOV	
Chaikovsakaya 16	Physikalische Zeitschrift der Sowjet-Union (*stopped after March, 1938*)
LENINGRAD	
The Akademie der Wissenschaften	Bulletin de l'Academie des Sciences Mathématiques et Naturelles
MOSCOW	
De l'Académie des Sciences de l'URSS	Comptes Rendus (Doklady)

Publishers	Journals
De l'Académie des Sciences de l'URSS	Bulletin de l'Académie des Sciences de l'URSS classe des Sciences Mathematiques et Naturelles
UKRAINE	
Academie des Sciences d'Ukraine, Kyive	Journal du Cycle Physique et de Chemie
"	Journal du Cycle Mathématique
"	Bulletin de la classe des Sciences Physiques et Mathèmatiques

UNITED STATES OF AMERICA

Publishers	Journals
ALLEGHENY CITY	
Allegheny Observatory of the University of Pittsburgh	Publications of the Allegheny Observatory
BOSTON	
American Academy of Arts and Sciences	Proceedings of the American Academy of Arts and Sciences
"	Memoirs of the American Academy of Arts and Sciences
CALIFORNIA	
The Mount Wilson Observatory	Contributions from the Mount Wilson Observatory
"	Communications from the Mount Wilson Observatory
"	Report of the Director of the Mount Wilson Observatory
University Library	Publications in Zoology, University of California
Lick Observatory, University of California	Lick Observatory Bulletin
CAMBRIDGE MASS	
Massachusetts Institute of Technology	Journal of Physics and Mathematics

Publishers	Journals
CHICAGO	
The University of Chicago	Astrophysical Journal
LAWRENCE, KANSAS	
The University of Kansas	Science Bulletin
MICHIGAN	
Observatory Library, University of Michigan	Publications of the Observatory of the University of Michigan
NEW YORK	
Bell Telephone Laboratories	Bell Telephone System Technical Publications
American Telephone and Telegraph Company	Bell System Technical Journal
Roosevelt Wild Life Forest Experiment Station	Roosevelt Wild Life Annals
The American Museum of Natural History	American Museum Novelties
New York Academy of Sciences	Annals of the New York Academy of Sciences
American Institute of Physics	Review of Scientific Instruments
„	Journal of Chemical Physics
NEW HAVEN, YALE	
Astronomical Observatory of Yale University	Transactions of the Astronomical Observatory, Yale University
Secretary, American Journal of Science	American Journal of Science
PHILADELPHIA	
The Franklin Institute of the State of Pennsylvania	Journal of the Franklin Institute
American Philosophical Society	Proceedings of the American Philosophical Society
Academy of Natural Sciences	Proceedings of the Academy of Natural Sciences of Philadelphia
	Miscellanea
	Library Annual Report

Publishers	Journals
WOODS HALE, MASS	
Marine Biological Laboratory Library	The Biological Bulletin
WASHINGTON	
The National Academy of Sciences	Proceedings of the National Academy of Sciences
Smithsonian Institute	Publications
Department of Commerce, Bureau of Standards	Publications of the Bureau of Standards
The Commissioner of Fisheries	Publications

APPENDIX 5

Journal subscribed by the National Academy of Sciences, India, during the year 1938

GENERAL

Publishers	Journals
Hirschwaldsche Buchhandlung, Berlin, N W 7	Die Naturwissenschaften (*Stopped after May, 1938*)

APPENDIX 6

LIST OF PAPERS COMMUNICATED TO THE ACADEMY DURING JANUARY 1938—DECEMBER 1938

1. Parachor and velocity of sounds in metallic elements by Binayendra Nath Sen, Chemistry Department, Burdwan Raj College, Burdwan
2. On the distance of closest approach of atoms by Binayendra Nath Sen, Chemistry Department, Burdwan Raj College, Burdwan
3. On a physico-chemical theory of photo-electric threshold by Binayendra Nath Sen, Chemistry Department, Burdwan Raj College, Burdwan
4. On a physico-chemical theory of ionisation of atoms on the basis of strain by Binayendra Nath Sen, Chemistry Department, Burdwan Raj College, Burdwan
5. Chemical examination of the fruits of *Physalis peruviana* or Cape Gooseberry, Part III, by Jagraj Behari Lal, Chemistry Department, University of Allahabad.
6. Study of F-region ionisation at Allahabad by B D Pant and R R. Bajpai, Physics Department, University of Allahabad.
7. On a new species of the genus *Astiotrema* Looss (1901) from the intestine of a fresh water fish, *Clarias batrachus* (from Lucknow) by J Dayal, Department of Zoology, Lucknow University
8. On the occurrence of *Skrjabinema ovis* (Skrjabin 1915) in India by M Abdussalam, Punjab Veterinary College, Lahore
9. The genito-urinary system of the Indian ground squirrel (*Funambulus palmarum*) by M A H Siddiqi, Department of Anatomy, K G Medical College, Lucknow
10. Colour and chemical constitution The organic and inorganic salts of diphenylvioluric acid by Satya Prakash and Sikhibhusan Dutt, Chemical Laboratory, University of Allahabad
11. Indigoid dyestuffs derived from chrysoquinone by V L Varma and Sikhibusan Dutt, Chemistry Department, University of Allahabad
12. Studies on the trematode parasites of fishes A new trematode, *Nizamia* hyderabadi, n gen, n sp from the intestine of a fresh water fish, *Ophiocephalus punctatus*, by J Dayal, Zoology Department, Lucknow University
13. Caustic soda and alumina from salt and bauxite (a new process of manufacture) by V S Dubey, Y P Varshney and R. S Sharma, Department of Geology, Hindu University, Benares

14 Notes on the microscopic studies of the igneous rocks of Elephanta, Trombay and Salsette islands and Parnera hill by A S Kalapesi and R N Sukheswala, St Xavier s College, Bombay

15—22 Studies on the effect of alcohol on the metabolism of green leaves, Parts I—VIII by U N Chatterji, Botany Department, University of Allahabad

23 New avian trematodes (Family Diplostomidæ) from Indian birds by R. D Vidyarthi, Zoology Department, University of Allahabad

24 On the formation of Liesegang rings in the presence of precipitates by Binayendra Nath Sen, Chemistry Department, Burdwan Raj College, Burdwan

25 Mathematical theory of a new relativity, Chapter XVI, Generalised gravitation by Sir S M Sulaiman, Judge, Federal Court of India, New Delhi

26 The solution of certain types of differential equations by A C Banerji and P L Bhatnagar, Mathematics Department, University of Allahabad

27 The fate of the Duct of Cuvier in man and certain other mammals by M A. H Siddiqi and R. V Singh, Department of Anatomy, K G Medical College, Lucknow

28 Changes in respiration and H-ion concentration in wounded potato tubers by B N Singh and M L Mehta, Institute of Agricultural Research, Hindu University, Benares

29 Annotated list of helminths from domesticated animals of Burma, Part I (Trematoda) by R. C Chatterji, Helminthological Institute, University of Rangoon, Burma

30 Tungsten and molybdenum powder in organic synthesis by Gauri Shankar Basu and Sikhibhusan Dutt, Chemistry Department, University of Allahabad

31 Cadmium powder as a synthetic reagent by Anil Chandra Chatterji and Sikhibhusan Dutt, Chemistry Department, University of Allahabad

32 Composition of Patent Still molasses fusel oil of Indian origin by Sikhibhusan Dutt, Chemistry Department, University of Allahabad

33 A new strigeid trematode of the genus *Crassiphiala* V Haitsma 1925 (Family Diplostomidæ Poirier) from an Indian King-fisher by B P Pande, Zoology Department, University of Allahabad

34 On two new trematodes from Indian Cyprinoid fishes with remarks on the genus *Allocreadium* Looss by B P Pande, Zoology Department, University of Allahabad

35 A note on the telescope method for determining the focal length of lenses and mirrors by Sukhdeo Behari Mathur, Physics Department, University of Delhi

36 Chemical examination of the essential oil of *Ocimum canum* by Jagat Narain Tayal and Sikhibhusan Dutt, Chemistry Department, University of Allahabad

37 F-region ionisation in June 1938 at Allahabad by K B Mathur and G R Toshniwal, Physics Department, University of Allahabad

38 Osculating quadrics of a ruled surface by R Behari, Mathematics Department, University of Delhi

39 On the trematode genus Lyperosomum Loss, 1899 (Dicrocœliidæ) with a description of two new species from India by B P Pande, Zoology Department, University of Allahabad

40 Two new species of the trematodes from *Anhinga melanogaster*, the Indian darter or snake-bird by B P Pande, Zoology Department, University of Allahabad

41 Changes in the viscosity of agar sol with temperatrue by S N Banerji and S Ghosh, Chemistry Department, University of Allahabad

42 Changes in the viscosity of agar sol with concentration by S N Banerji and S Ghosh, Chemistry Department, University of Allahabad

43 Constitution of Santalin by Jagraj Behari Lal, Chemistry Department, University of Allahabad

44 Migration of para halogen atom in a derivative of meta-cresol by A B Sen, Chemistry Department, Lucknow University

45 Further studies of the F-region ionisation at Allahabad by R R. Bajpai and B. D Pant, Physics Department, University of *Allahabad*

APPENDIX 7

Financial Statement from January 1, 1938 to December 31, 1938

Receipts	Rs.	a.	p	Expenditure	Rs	a.	p
Opening Balance on the 1st January 1938	1 182	15	3	Establishment	1,484	0	0
Subscription from Members	1.575	0	0	Contingency (including printing postage stamps, stationery allowance, etc) ..	705	2	6
Grant from the Government, United Provinces for 1937–38	2,000	0	0	Printing of the *Proceedings* of the National Academy of Sciences, India	1 432	4	0
Grant from the Government, United Provinces for publication of the *Symposium on Problems of Power Supply in India*	500	0	0	Binding of journals	1	8	0
				Bank charges on outside cheques	12	10	0
Grant from the Imperial Council of Agricultural Research, New Delhi	500	0	0	Available Cash Balance on the 31st December, 1938, with the Imperial Bank of India, Allahabad	3,183	8	9
Donation from His Exalted Highness the Nizam's Government, Hyderabad-Deccan	1,000	0	0				
Sale of the Proceedings of the National Academy of Sciences, India	59	14	0				
Bank Commission on outside cheques	1	4	0				
Total	6,819	1	3	Total	6,819	1	3

Accounts compiled by —

P C Mukerji,
Of the Office of the National Academy of Sciences, India

H R. MEHRA,
M.Sc, Ph D (Cantab.)
Hony Treasurer,
National Academy of Sciences, India

Printed by K Mittra, at The Indian Press, Ltd., Allahabad

I. A. R. I. 75.

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